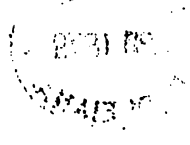
BIRT'S HAND BOOK OF THE LAW OF STORMS

NEW AND REVISED EDITION



HANDBOOK

OF

THE LAW OF STORMS;

BEING

A DIGEST OF THE PRINCIPAL FACTS OF REVOLVING STORMS.

FOR THE USE OF COMMANDERS IN HER MAJESTY'S NAVY AND THE MERCANTILE MARINE.

BY

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A New Edition, with Important Additions.

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PREFACE.

It is frequently the custom, in introducing a new work to the notice of the public, to offer some remarks, by way of apology for the author's intrusion into the rank of writers already received as acknowledged authorities on the subject in question. It is, however, conceived that the following pages do not stand in need of such an introduction: the time has arrived when the rotation of storms may be treated not in the manner of an investigation, but as an acknowledged fact. It is true the names of Capper, Redfield, Reid, Piddington, and Thom, must ever be associated with the literature of storms; and a most noble superstructure has been raised by the indefatigable exertions of these gentlemen. It is, however, not the less true that the science of storms has arrived at that stage of its development that, in works professedly written for the guidance of seamen, much that is found in the volumes of the above-named writers may now be dispensed with. Most of them consist of collections of individual facts, placed in a lucid and intelligible manner before the mind of the seaman; but in the application of the principles developed he has to exercise his own judgment, to regard the details more or less with the eye

of science, and to draw his conclusions from the individual cases before him. The science of storms has passed from the stage of the development of its laws to the reception in the minds of most scientific men, of a great and grand meteorological fact, composed it may be of separate and individual facts, which, with some degree of propriety, lay claim to the designation of the "facts of revolving storms." Now, it is the object of the following pages to place before the reader such a digest of these facts, arranged in a natural and consecutive order, and succeeded by an announcement of the phenomena resulting from them, that a seaman, without the trouble of consulting logs, or arranging isolated records of the wind, weather, &c., may at once learn his position in a cyclone, and ascertain the proper course to adopt for the purpose of avoiding its fury.

Not many years had elapsed after the first publication of this work, before Meldrum, at the Mauritius, commenced his studies of storms in the Indian Ocean, which have resulted in a further development of the nature of storms generally, by shewing that in many cases the movement of the wind is of a spiral character, which modifies very materially the bearing of the centre and margin from the ship, a fact greatly calculated to perplex the mariner. The requisite additions for aiding commanders in applying this increased knowledge, will be found in the body of the work, and it is hoped that the intricacy introduced by spiral storms will be rendered much easier to overcome by these additions.

With this view, as well as to condense the work into a compass suitable for extensive use on shipboard, all reference to existing logs and previous writers, except in a few important instances, has been dispensed with. Any seaman, desirous of making himself acquainted with the mode of developing the "Law of Storms," and determining the essential "facts of hurricanes," can, with great advantage, study the works of all the above-mentioned writers; but, for practical purposes, it is hoped the following digest will be found sufficient to announce the danger and apply the remedy. In every department of the work assiduous attention has been directed to the determination of the position of the vessel without the aid of storm cards or horns, hurricane circles, storm pointers, or any other kind of instrument, the barometer alone excepted, the commander depending solely on the direction and hauling of the wind for this important information; for, if it be true that the "Law of Storms," as developed by Mr. Redfield and Col. Reid, is invariable in both hemispheres, then the results, as detailed in this work, must necessarily follow; and if once the bearing of the centre of the storm, as determined by the direction of the wind and the position of the ship, in either semicircle, by its hauling, be deeply impressed on the mind, the commander has not the slightest difficulty, under any circumstances that may arise, of ascertaining his position.

It must not, however, from the comparative facility with which the "Law of Storms" enables us

to determine the position of a ship, be concluded that the science is in any way complete. Already one important fact has been added to our knowledge since this work first appeared, but we have yet much to learn, especially with regard to the varied directions in which storms move. Considerable attention has accordingly been bestowed on the storm-paths both of the northern and southern hemispheres, which, although of a less practical nature than some other portions of the work, may yet be found valuable, at all events in indicating further lines of research in this direction. Impressed with the idea that "abstract science," under all circumstances, bears remotely, if not immediately, on the wellbeing of society, we have not shrunk from placing before the public our views of the storm-paths in all localities, even at the risk of giving to our otherwise practical work the appearance of a scientific volume, and incurring the oft-repeated cry, when immediate benefit does not appear, of "*Cui bono?*"

The great value of increased information on this, and indeed every other branch of the science of storms, has induced a remark or two in the body of the work, to the effect that all such information will be acceptable, if forwarded to the Publishers. Both time and trouble may be saved by any communications of this nature being forwarded direct to the address below.

Where it has been deemed necessary to enunciate general rules as resulting from the essential phenomena of storms, such rules, in order to catch the

eye of the seaman, and to stand out as particular objects of study, are printed in a larger and different type; and, to render the work as extensively useful and as complete as possible, a copious index has been added, by the use of which a seaman may readily turn to any part of the volume bearing on his particular case. Those articles of greater utility are referred to under two or more heads.

STRATFORD, ESSEX,
August 20, 1878.

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ILLUSTRATIONS.

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It is by the judicious combination of *scientific* with *practical* knowledge that we may reasonably expect further improvement in this department of navigation. The commander who possesses a thorough knowledge of the practice of navigation, and with this combines as thorough a knowledge of the "LAW OF STORMS," is much better able to manœuvre his vessel when the emergency arises, than he who, although exceedingly skilful in his art, is entirely ignorant of the beautiful and unerring laws that unceasingly operate in the wild, impetuous, and irresistible HURRICANE.

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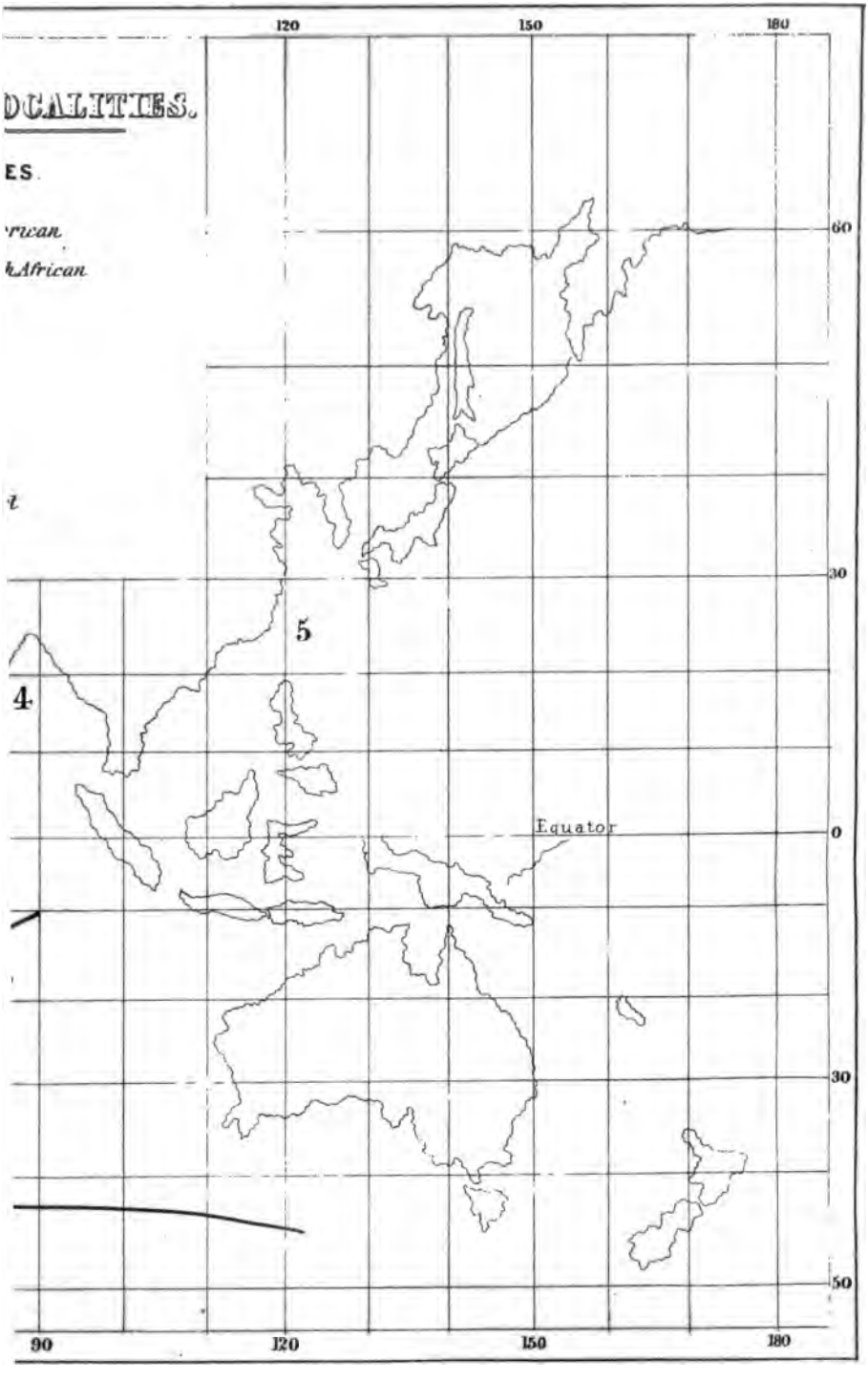
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THE HANDBOOK

OF

THE LAW OF STORMS.[1]

INTRODUCTION.

1 THERE is no branch of meteorology that is calculated to be of greater importance to the commanders of vessels, nor any class of observations bearing upon the wind and weather that, in the present state of our knowledge, is likely to exert so powerful an influence on the interests of our shipowners and merchants, than that department of the science which

Importance of a knowledge of storms to sea commanders, shipowners, and merchants.

[1] It may be useful here to quote Mr. Piddington's admirable definition of the word "Law."

"Theory and Law. The seaman may best understand these two words by his quadrant. As long as people who paid attention to these things *supposed* that light, when reflected from a mirror, was always so at a certain angle, depending somehow on the direction in which the original light fell upon it, this was a THEORY. When it was proved by experiment that the angle of reflection was *always* equal to the angle of incidence, this became the LAW of reflection; and when Hadley applied it to obtain correct altitudes, and to double the angle by the two reflections of the quadrant, he used it for a nautical object of the first importance and of daily practical utility. These are the three great steps of human knowledge and progress:—the THEORY or *supposition*, that a thing always occurs according to certain rules; the *proof* or LAW, that it does and will always so occur; and the *application* of that Law to the business of common life."—PIDDINGTON'S *Sailor's Horn Book*, page 7.

The *proofs* of the "Law of Storms," alluded to in the above quotation, having now accumulated to a very considerable extent, the Handbook is principally devoted to the *third* step of human knowledge, viz., the application of the "Law of Storms" to the business of common life.

has peculiar reference to the "Law of Storms," and that class of observations which furnishes the investigator of the phenomena of nature with the data for placing in a simple and intelligible manner before the mariner, those rules by which he may so manœuvre his ship, as not only to avoid the dangerous portions of a cyclone, but to take advantage of certain "hurricane winds" to bring him on his course.

History of the investigation into the nature of storms.

2. The history of the *investigation* of storms coincides with the present century. It is generally supposed that at the beginning of the present century the late Colonel Capper, who held an appointment on the coast of Coromandel, directed attention to the gyratory phenomena of the hurricane, and that, previous to the appearance of his work on Winds and Monsoons, the fact of their rotation was unknown. He, however, has this remarkable passage in his Preface:—

Col. Capper's views.

"When the thought first occurred of attempting to investigate the causes of the winds, great doubts of success arose in my mind, from the apparent number and variety of them—even of those within the tropics, where they are most regular; but as I proceeded, these difficulties gradually vanished, for the tempest, the tuffoon or typhon, the hurricane, and the tornado, were soon discovered to be mere distinctions without the shadow of difference; and only the English, the Greek or Persian, the Italian or Spanish name, for a whirlwind."

From this extract we learn that the idea of rotation in a hurricane must be very old, as various nations in different parts of the world gave to the same collection of meteorological phenomena similar names, each involving the idea of a *whirlwind*. "This point gained," says Colonel Capper, he proceeded to inquire, not particularly into the nature of these whirlwinds, but into that of the trade-winds and monsoons. He has, accordingly, but rather casually, noticed in the course of his investigations, the principal phenomena of cyclones; and his remarks indicate that the fundamental

idea embodied in the above terms, being present to his mind, he was *even then able* to specify with considerable accuracy, the rotation, size, localities, and season of hurricanes. The following quotations will suffice :—

In describing the setting in of the N.E. monsoon in the Bay of Bengal, the Colonel remarks :—"But the tremendous gales, or rather hurricanes, which sometimes blow in the gulf at this season" (*i.e.*, when the N.E. wind prevails), "and bear down everything before them, seldom happen precisely at the beginning of the monsoon; nor does it appear that they are the effect of a current of air like the monsoon, blowing constantly from the same quarter for several months; but rather resemble whirlwinds, which proceed principally from some sudden change in the upper regions of the atmosphere, and which, though extremely violent, are merely local and temporary." Storms of the Bay of Bengal rotatory.

After referring to some violent hurricanes mentioned in Ormes' *History of Hindustan*, the Colonel has this important remark :—"All these circumstances properly considered, clearly manifest the nature of these winds, or rather positively prove them to be whirlwinds, whose diameter cannot be more than 120 miles, and the vortex seems generally near Madras or Pulicat, where a branch of the Ballagat mountains extends towards the sea. Those which happen in the N.E. monsoon, generally fall with most violence within a few leagues of this place, and never, I believe, reach to the south of Porto Novo." Size of the Bengal hurricanes.

Colonel Capper further remarks—"From these accounts it seems very clear that hurricanes never happen at the breaking up of the monsoons, nor precisely at their commencement, but rather some time after the change, and that they are local and of short duration. But this description of them is not confined to the Malabar coast, nor to that of Coromandel; they rage with equal, if not superior violence, in the Southern Hemisphere, particularly about the latitude

Storms of the Indian Ocean.

of 20° S., near the French islands, where many ships have been in great danger of perishing from their effects, amongst the rest the Ilchester Indiaman, in the year 1757."

Localities and seasons of hurricanes.

The following extract gives a brief summary of the localities and seasons of hurricanes:—"Thus, then, it appears that these tempests or hurricanes are tornadoes or local whirlwinds, and are felt with at least equal violence on the sea-coast, and at some little distance out at sea. But there is a material difference in the situation of the sun when they appear at different places. On the coast of Coromandel, for example, they seldom happen, particularly to the northward, except when the sun is in the opposite hemisphere. On the Malabar coast they rage with most violence during the monsoon, whilst the sun is almost vertical. Near the island of Mauritius, they are felt in January, February, and March, which may be deemed their summer months. And in the West Indies, according to Mr Edwards' *History of Jamaica*, the hurricane season begins in August and ends in October."

Application of the theory.

The following extracts will shew that Colonel Capper was just on the eve not only of ascertaining the general laws of the rotation of storms, but also of applying the theory:—"It would not," he says, "perhaps be a matter of great difficulty, to ascertain the situation of a ship in a whirlwind, by observing the strength and changes of the wind. If the changes are sudden and the wind violent, in all probability the ship must be near the centre or vortex of the whirlwind; whereas, if the wind blows a great length of time from the same point, and the changes are gradual, it may be reasonably supposed the ship is near the extremity of it." Again, in speaking of the homeward-bound voyage from India, he says —"To avoid these inconveniences, therefore, I should recommend to passengers who can command their time, to embark in India in the month of January. It is possible, indeed, they may meet with a gale of wind, or rather a whirlwind,

in the latitude of the French islands; but this seldom happens, and, with proper precautions, can hardly be considered as dangerous."

3. While from the foregoing extracts we find Colonel Capper speaking confidently as to the fact of the rotation of the air in large storms, and conceiving it not to be difficult to determine the position of a ship in a hurricane—enunciations that have evidently laid the foundation for the solid and useful superstructure that has since been raised—he does not appear at all to have apprehended the *order* of rotation, nor its *reversion* in either hemisphere. Neither does he appear to have had the least conception of the routes of the storms themselves; these particulars, with several others, have been developed by later inquiries. A very remarkable instance occurs in the course of his work, in which certain phenomena now known to result from a rotatory storm were considered by the Colonel to receive a sufficient explanation from a very different hypothesis.

Precise extent of Col. Capper's views.

4. About sixty years before Colonel Capper's book was published, the immortal Franklin intended to observe an eclipse of the moon, but was prevented by a north-east storm, which came on about seven, with thick clouds as usual. This was at Philadelphia. When the Boston post arrived, he found from the newspaper that the beginning of the eclipse had been well observed there, and as the distance of Boston was about 400 miles north-east of Philadelphia, he was not a little puzzled at the circumstance, that a storm from the north-east should rage at one locality, while at another, *still further to the north-east*, the weather should be clear and fine; and this perplexity was increased upon his finding that the storm did not commence at Boston until nearly eleven o'clock—about four hours later than at Philadelphia; so that *apparently* the north-east wind had travelled backwards. It appears that Franklin had not the slightest idea of a rotating storm, at least as sweeping over

Franklin on a north-east storm in America.

the coasts of America, for he endeavours to explain the phenomena by supposing "some great heat and rarefaction of the air in or about the Gulf of Mexico; the air thence arising has its place supplied by the next more northern, cooler, and therefore denser and heavier, air; that being in motion, is followed by the next more northern air, &c., &c., in a successive current, to which current our coast and inland ridge of mountains give the direction of north-east, as they lie N.E. and S.W." This explanation Colonel Capper considered as curious and satisfactory; he says:—"Dr. Franklin, in his correspondence with Mr. Alexander Small, dated the 12th of May 1760, affords us a proof that a current of air in America moved many hundred miles during a violent N.E. storm, probably from the Gulf of Mexico to Boston, and which he accounts for in a very curious and satisfactory manner." It is now well known that the north-west margins of the northern Atlantic hurricanes sweep over the land, producing the *successive* appearances of N.E. winds, at stations situated north-easterly of each other.

Digest of facts already accumulated.

5. The series of facts announced by Franklin may be considered as among the earliest recorded phenomena at all bearing on the nature of revolving storms; and in the facts themselves, and the subsequent reasoning, we see the importance of a great accumulation of facts to substantiate a theory.[2] At the present time, the facts that have been accumulated are so numerous, and have been so well collated by Redfield, Reid, Piddington, and Thom; and latterly by Meldrum, of the Mauritius, Gastrell, Blanford, and Wilson, of Calcutta, and other meteorologists—who have determined that in certain localities the motion of the wind in large storms, instead of being truly *circular*, becomes *incurving* or

[2] The *earliest* occurs in Captain Langford's paper on the West Indian hurricanes, "*Philosophical Transactions*," 1698, in which the hurricanes are considered as whirlwinds. The Captain describes their progression, and gives some limits for them.

blowing towards the vortex, as indicated by Redfield in the Atlantic storm of 1831, and endorsed by Piddington, although not worked out by these writers—that we are able to lay before the commanders of the mercantile marine such a digest of them as may materially assist not only in determining the positions of vessels, but also in affording the means of turning even the hurricane to advantage, and profiting by what are called the tail winds of the storm.

In offering this digest to the attention of commanders, we shall consider the most important features of revolving storms, as made out by the latest inquiries, under the following heads :— Heads of digest.

1. Order of Rotation.
2. Progressive Motion.
3. Barometric Phenomena.
4. Phenomena of Recurving.
5. Storm-paths of the Northern and Southern Hemispheres.
6. Meteorological Signs preceding and accompanying Hurricanes.
7. Hurricane Seasons.
8. Storm Waves and Cross Seas.
9. Phenomena in the Northern Atlantic.
10. „ „ Bay of Bengal.
11. „ „ China Seas.
12. „ „ Indian Ocean.
13. Atmospheric Waves.

CHAPTER I.

CIRCULAR AND INCURVING STORMS.

Motion of air *against* the apparent course of the sun in the northern and southern hemispheres.

6. *Circular Storms.*—The extracts from Colonel Capper's work sufficiently introduce us to the fundamental idea of a cyclone — viz., that of a revolving body of air — but they furnish us with no information as to the direction of this rotation, or its order in either hemisphere. The latest inquiries bearing on this head acquaint us with the very important fact, that there are two kinds of destructive storms, viz., cyclones or *revolving* storms, and spirals or *incurving* storms, and that *in both hemispheres the air in either kind of storm revolves or incurves* AGAINST *the sun.* In the northern hemisphere, the course of the sun is from east by south to west, or, according to the letters, E. S. W. N., consequently the rotation of the air in the cyclone is from west by south to east, or N. W. S. E. In the southern hemisphere, the course of the sun is reversed, viz., from east by north to west, or, according to the letters, E. N. W. S.; the rotation of the air in the cyclone being from west by north to east, or N. E. S. W. From these facts it is easy to perceive that the rotation in each hemisphere is the

Fig. 1.

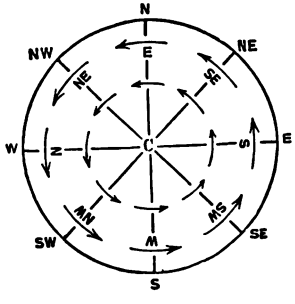
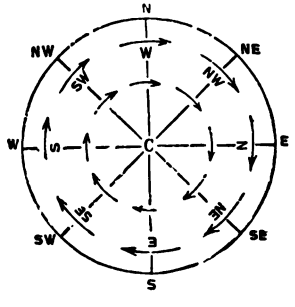


Fig. 2.



opposite of the other, and that, if we regard the motion of the hands of a watch as illustrating the rotation of the air, we find that the northern storms revolve in a direction contrary to the hands, and the southern coincident with them.

7. *Incurving Storms.*—According to Mr. Clement Ley (*Symon's Monthly Meteorological Magazine*, March 1874, p. 21), the departure from a true circular movement of the wind in a northern storm progressing towards the north-east, is shewn in fig. 3, the incurvature being but slight in the hinder part of the storm, but rather considerable in the advancing semicircle.[8] If, however, the reverse of Mr. Meldrum's incurving storm in the southern hemisphere be taken as the type of a similar storm in the northern, it will be represented by fig. 4.

Fig. 3.

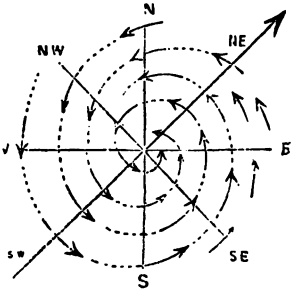
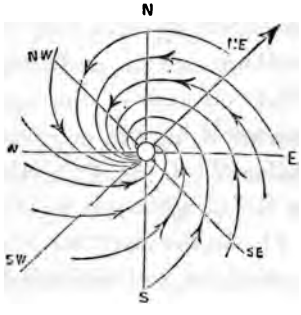


Fig. 4.



Deductions from the Order of Rotation in a Circular Storm.

8. A very important deduction from the order of rotation is the following:—Each portion of the margin of a revolving storm is characterised by a certain wind, which may with

[8] Whenever an incurving storm of the Ley type is referred to in the following pages, it will be distinguished thus, "Incurving storm;" a Meldrum storm will be designated "Spiral."

great propriety be termed "a hurricane wind;" and further, that each hurricane wind, when referred to its position on the margin, is found to blow *eight* points from that margin reckoned *with* the sun. Thus, on the northern margin, in the northern hemisphere (see fig. 1), an easterly wind is found; on the southern margin a westerly; on the western margin a northerly; and on the eastern margin a southerly. In the figure referred to, the outer letters designate the margins, and the inner the hurricane winds.

Marginal winds, northern hemisphere.

9. In the southern hemisphere the reversion of the rotation produces a reversion of hurricane winds. Thus, on the northern margins of storms south of the equator (see fig. 2), the wind blows from the west; on the southern margin, from the east; on the eastern margin, from the north; and on the western, from the south.

Marginal winds, southern hemisphere.

10. If the area covered by the storm be divided into four quadrants by diameters drawn from the northern to the southern margin, and from the eastern to the western, the winds on each of the radii will be similar to the winds characterising the margins terminating them; thus, on the radius N.—C (fig. 1), northern hemisphere, the wind is east; on E.—C, south; on S.—C, west; and on W.—C, north.

Radial winds, northern hemisphere.

11. As the marginal winds were reversed in the southern hemisphere, and the radial winds are in all cases the same as the marginal winds, so on the radius N.—C (fig. 2) southern hemisphere, the wind will be west; on E.—C north; on S.—C, east; and on W.—C, south.

Radial winds, southern hemisphere.

12. But by far the most important deduction is the bearing of the centre from the ship, which is always *eight* points, reckoned from the direction of the wind *with* the sun; and this obtains both in the northern and southern hemispheres, for, the rotation being reversed with the course of the sun, the bearing of the centre remains the same. Thus, in fig. 1, northern hemisphere, a ship on the radius C—N.E. has the centre bearing S.W., the wind being S.E., while in the

Bearing of the centre *eight* points *with* the sun.

southern hemisphere (fig. 2), a ship on the same radius will still have the centre bearing S.W., but the wind will blow from N.W.; which is also in accordance with the deduction, that the centre bears eight points from the wind reckoned with the sun, the course of the sun being E., N., N.W., W., S.W.

13. From these deductions a very useful and highly important *general rule* results, viz.:—

General Rule.

THE *centre* OF THE STORM BEARS EIGHT POINTS FROM THE DIRECTION OF THE WIND AT THE SHIP RECKONED *with* THE SUN; AND THE *margin* BEARS EIGHT POINTS ALSO FROM THE DIRECTION OF THE WIND AT THE SHIP RECKONED *against* THE SUN.[4]

Fig 5.

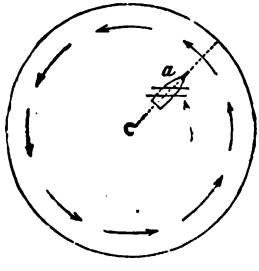


Fig. 6.

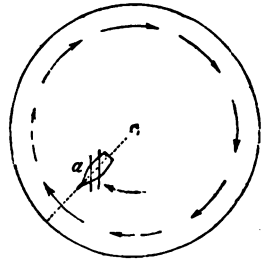


Illustration.

14. The ship *a*, in figure 5, northern hemisphere, has the wind from the S.E. Eight points *with* the sun give S.W. the bearing of the *centre*; eight points *against* the sun N.E., for the bearing of the margin. In the same way, the ship *a*, in figure 6, southern hemisphere, has the wind also from S.E., but in this case, eight points *with* the sun give N.E.

[4] In consequence of the development of the incurving theory of storms, this rule requires modification. According to fig. 3, the departure from a true circular movement is *greatest* in the anterior semicircle; but according to fig. 4, it is *least* in the anterior semicircle; and these departures affect the direction of the wind on all the radii, but differently, according to the point of the compass to which the storm may be progressing. The extent of deviation will be given in each of the following "*Deductions from the progressive motion*" (p. 14, *et seq.*) It may, however, be essential at once to give the winds on the eight

for the bearing of the *centre*, and eight points *against* the sun S.W. the bearing of the margin, the reversion of the rotation in the opposite hemisphere giving rise to the reversion of the phenomena.

CHAPTER II.

PROGRESSIVE MOTION.

Progressive Motion—Deductions from the Progressive Motion—Application of the Combined Results of the Progressive and Rotatory Motions of Storms—Division of the Storm Area—Classification of Hurricane Winds—Practical Results.

15. The above enunciation of the order of rotation in a circular storm, and the phenomena resulting therefrom, may have reference to a cyclone, either stationary or in motion; in both cases the hurricane winds, and the bearings of the centre and margin, will be the same; the result of all our investigations, however, up to the present moment, agree in developing the important fact, that revolving storms *are not stationary;* the entire mass of air thrown into a state of rotation moves bodily forward, producing a class of phenomena, differing from—but not less important than—that arising from the rotation; in fact, a clear comprehension

Revolving storms in motion.

principal radii according to the two theories—Ley's and Meldrum's—as in the following table constructed for the Northern Atlantic. Motion towards the N.E.

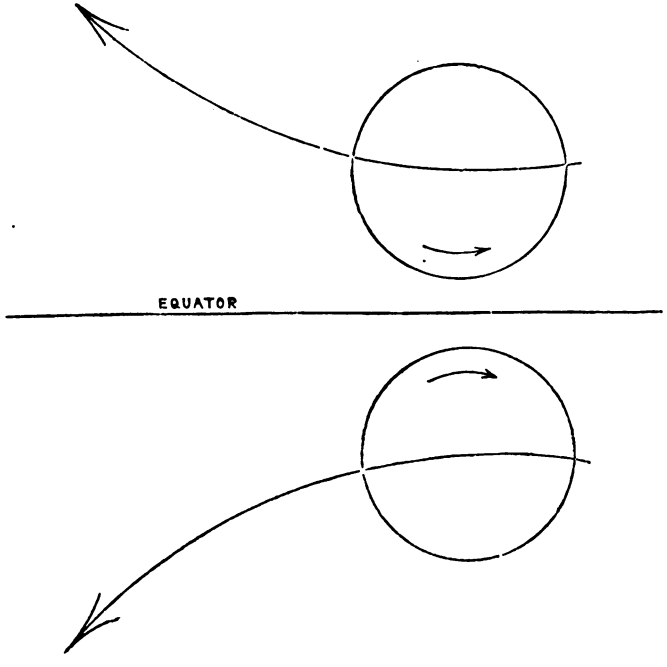
TABLE I.

	Winds.		Bearing of Centre.	
Rad.	Ley.	Mel.	Ley. Pts.	Mel. Pts.
N.	E. by N.	E.	9	8
N.E.	E.S.E.	S.E.	10	8
E.	S. by E.	S.S.E.	9	10
S.E.	S.W. by W.	S.	9	12
S.	W. by S.	S.W.	9	12
S.W.	N.W.	W.	8	12
W.	N.	W.N.W.	8	14
N.W.	N.E. by N.	N.	9	12

of the phenomena arising from the progressive motion is quite as essential for the safety of a vessel in a storm as a distinct apprehension of the phenomena of rotation.

16. The progressive motion—as the rotatory—appears to be very considerably influenced by the sun, or rather by the rotation of the earth. The terrestrial equator, so far as our present knowledge extends, is the line of demarcation

Fig. 7.



between exhibitions of different and opposite classes of phenomena :—opposite in the case of the rotation of storms : different in that of their progression. In both hemispheres, storms move from east to west during the early part of their course, and from west to east during the latter; and, in addition, they may be described as moving, *under all circumstances*, obliquely towards the poles.[5] No instance

Storms either north or south of the equator.

[5] Several instances of a different character have come under notice ; they will be referred to in the chapter on Storm-paths.

is to be found on record of a hurricane having been encountered on the equator, nor are there any indications of one having crossed the equator. A remarkable instance has occurred of *two* raging at the same time on the same meridian; they were ten degrees apart, having the equator between them, and a vessel that crossed the equator while they were raging experienced a *strong westerly gale*, evidently the result of the hurricane winds of the southern and northern margins of the two cyclones respectively. This example is in perfect keeping with the cyclonic theory, for it is only in cyclones that strong westerly winds are found due north and south of the equator on the southern and northern margins. In spiral, the winds on these margins vary from south to west in the Northern Hemisphere, and are mostly north-westerly in the Southern. (See fig. 7.)

17. The storm-path, as referred to the aqueous or terrestrial surface of the globe, of course, has reference to the area at once or successively covered by the cyclone; but if we contemplate the *path of the centre alone*, it will be a line traced on the surface of the ocean or land over which it passes, and may, with great propriety, be termed the *axis-line*.

The axis line.

Division of storms into semi-circles.

18. The next important result of the progressive motion of storms, is the division of cyclones into semicircles; the axis-line determines this: all that portion of the cyclone to the *right* of the axis-line is called the *right-hand semicircle*, in the same sense as the right-hand side of a ship is called the *starboard* side; and, on the contrary, all that part of the cyclone to the *left* of the axis-line is called the *left-hand semicircle*, in the same sense as the left-hand side of a ship is called the *port* side: also a diameter tranverse to the axis-line will divide the storm area into the anterior and posterior semicircles.

Right-hand semicircle.

Left-hand semicircle.

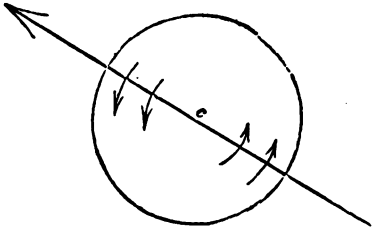
Deductions from the Progressive Motion.

19. These divisions of a cyclone into the axis-line, the

right and left-hand, and anterior and posterior semicircles, especially when combined with the rotatory or incurving motion, furnish some very important and valuable deductions, especially with regard to the hauling of the wind. If the axis-line pass over a vessel, it is evidently equivalent to the vessel remaining on any given radius of the storm; and as we have seen that any one radius is characterized by a similar wind to that blowing on the margin, terminating that particular radius (section 10), it is clear, that when the axis-line passes over a ship, she experiences *only one wind* during the time the radius is passing her; and when this is succeeded by the radius completing the diameter of the storm, she experiences a wind from the *opposite* quarter, provided she is in a circular and not in an incurving or spiral storm. All vessels that have passed through the centres of hurricanes invariably agree as to the fact of *a calm* existing in the centre; and it appears to be no less true, that the force of the wind *increases* from the margin to the calm, and, conversely, *decreases* from the calm to the margin; we have, consequently, the following important rule :—

Phenomena during the passage of the axis-line.

Fig. 8.



Calm in the centre of a cyclone.

IF A SHIP BE, AND REMAIN FOR ANY LENGTH OF TIME, ON THE AXIS-LINE OF A CYCLONE, SHE DOES NOT EXPERIENCE *any change* OF THE HURRICANE WIND. IT IS OBSERVED ONLY TO INCREASE IN FORCE, UNTIL THE CENTRE APPROACHES, WHEN A CALM ENSUES. THIS CALM, MOSTLY OF ABOUT HALF AN HOUR'S DURATION, IS SUCCEEDED BY A WIND BLOWING FROM THE *opposite* QUARTER TO THAT PRECEDING THE CALM, AND WHILE IT CONTINUES, ITS FORCE DECREASES.[6]

General rule.

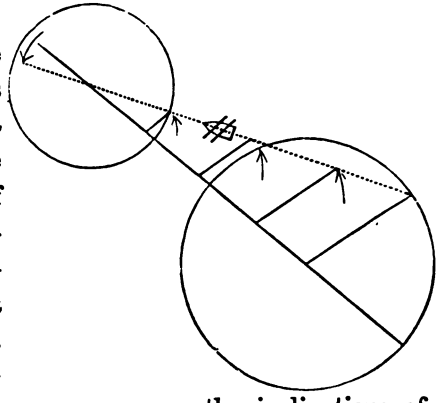
[6] This rule is only true for a circular storm. A commander overtaken in the Northern Hemisphere by a storm incurving on Ley's theory, and moving

*** In fig. 8, a ship passing through the hurricane from N.W. to S.E.—which is the same thing as the hurricane passing over the ship from S.E. to N.W.—experiences a N.E. wind, which increases in force until the calm occurs at *c*: the S.W. wind then springs up with inconceivable fury, but continues to decrease in force until the gale has passed.

Phenomena when the motions of a ship and hurricane are inclined to each other with certain relative velocities.

20. It is not absolutely necessary that the ship should be on the axis-line to experience the phenomena enunciated in the above rule; she may even be near the margin of a storm, on the radius at right angles to the axis-line, and yet experience precisely the same phenomena as if she were on the axis-line, with the storm apparently moving at right angles to its true course. The conditions necessary to produce these appearances are the inclinations of the two courses—*i. e.*, of the ship and hurricane—at such an

Fig. 9.



toward the north-west, will have a N.N.E., instead of a N.E., wind, the centre bearing S.E., or *ten* points from the wind: upon the centre passing him, the wind, instead of changing to S.S.W., which it would do in a circular storm, becomes S.W., the centre now bearing N.W., or *eight* points from the wind. On the Meldrum theory, the wind on the axis-line would be as in a circular storm, N.E. in the anterior semicircle; but upon the centre passing the ship, it would become S., instead of S.W., and the centre would bear *twelve* points from the wind at the ship, reckoned with the sun.

The following Table indicates the winds likely to be experienced upon the passage of the centre on both theories:—

TABLE II.

Axis Line.

Ley's Theory.			Meldrum's Theory.		
N.W.	N.	N.E.	N.W.	N.	N.E.
N.N.E.	N.E. by N.	N.E. by N.	N.E.	N.E.	N.N.E.
	Calm.			Calm.	
S.W.	S.W. by S.	S.W. by S.	S.	S.	S.

angle (not necessarily always the same), that while they are both progressing with such relative velocities as to preserve the same relative positions of the ship and centre of the storm, they are nearing each other, so that the tracks cross in the centre of the hurricane. (See fig. 9.) Under these circumstances, it becomes a question of vital importance *to know how to distinguish* between the two cases. Most storm writers advise that, when the commander is *perfectly satisfied* that he is on the axis-line, with a hanging wind, and that the centre is "coming down" upon him, he should put the ship before the wind,[7] and, by scudding, pass into the left-hand semicircle in the northern hemisphere, or into the right-hand semicircle in the southern, which will carry him *away* from the track of the centre; or rather, that he should edge away to the right or left-hand margin, according as he is in the northern or southern hemisphere. If, however, he were to do so upon finding the *wind to hang, at the same time increasing in force, with the barometer falling*, precisely the phenomena experienced on the *axis-line*, while he remained *on the radius, at right angles to it*, it is clear he would be rushing unconsciously into danger, as he would be scudding in the most dangerous quadrant—a course deprecated by every storm writer; or he would be departing too widely from the course he was desirous of pursuing.

Hanging wind, ship *not* on axil-line.

The only means by which a commander can distinguish between the cases of his being on the axis-line and on any radius inclined at any angle to it, the same phenomena being presented in both instances—and these, perhaps, are two of the most important cases that can occur—is by lying-to for a short time on the tack that will draw the

[7] In a spiral storm, under similar circumstances to those mentioned in this section, the wind would hang as in a circular storm; while, however, by scudding, he would cross the axis-line, and take up a better position in a circular storm; in a spiral storm he would gradually and surely approach the centre.

When to heave-to.

ship's head *from the centre.* The general state of the wind and weather, the gradual falling of the barometer, the necessity for shortening sail, and various meteorological indications, will sufficiently announce the proper time for bringing the ship to the wind, or rounding-to, for the purpose of settling this question. Much time may be gained, and a safe position taken up, by resorting to it early—*i. e.*, by the time the barometer has fallen half an inch, and it is necessary to put the ship under double-reefed topsails.[8] On no account whatever should the commander *assume* that he is involved in a circular storm, or that the course of any storm he may encounter is similar to any of those that have yet been traced, the variations of storm-paths being so great, as to render it extremely *uncertain* in what direction any given storm may be moving when first fallen in with.

When the vessel is hove-to—*not on the axis-line*—two classes of phenomena will present themselves, according as she is in advance of the radius at right-angles to the axis-line, on this radius, or behind it. In each case a veering of the wind *with* the sun will be experienced if she be in the right-hand semicircle in the northern hemisphere, or the left-hand in the southern, but the state of the barometer and the force of the wind will vary. When she is in advance of the radius, the barometer will fall, and the wind increase in force; but when she is on the radius, or behind it, the barometer will rise, and the wind decrease in force. In the first case, the bad weather will increase while the ship

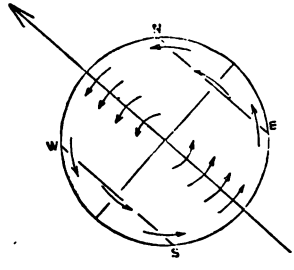
Phenomena when hove-to.

[8] It may probably be considered as a waste of time to lie-to at this early stage; but it must be remembered that, while "a common close-reefed topsail gale" is such "that no seaman cares for, and no seaworthy ship is hurt by," the violence from this point *increases with great rapidity to the centre;* so that, by lying-to, even under close-reefed topsails, the commander does so under great disadvantages, as, should he be in an advancing quadrant, or especially on the axis-line, his bad weather must increase, and before he can settle the question which prompted him to heave to, he may sustain much damage. In the case of a southerly "spiral," Mr. Meldrum suggests a fall of the barometer equal to six-tenths of an inch as the criterion on which to adopt precautionary measures.

remains hove-to, and the best manœuvre appears to be at once to put her head at right-angles to the wind, at the same time directed from the axis-line; this will immediately bring up the barometer, and enable her to carry more sail.[9] In the second instance, the cyclone is evidently leaving her in its wake, so that the vessel may resume her course as soon as the commander is satisfied that he can do so without running *after* the gale, and thus encountering the centre. It is, however, important that he should keep a sharp look-out for any change of direction in the course of the hurricane, or the point of recurvature, to which we shall direct particular attention hereafter.

21. A consideration of figures 1, 2, and especially 8, will shew that the single change and its modifications, mentioned in the preceding rule and its accompanying note, arise from the progressive, rotatory, incurving, and spiral motions combined. If the ship be in the right-hand semicircle, these combinations of the motions will produce other—but still very characteristic—phenomena: Suppose the passage of a ship in a circular storm to be represented by the line N.—E., fig. 10, the winds she will experience will be E., E.S.E., S.E., increasing in force, and S.E., S.S.E., S., decreasing in force. Here we see at a glance that the hauling of the wind is in accordance with the apparent course of the sun, the changes being from east to south, and the course of the sun in the heavens being in the same direction. So that, as a general principle arising from an extensive induction of individual cases, we find that

Fig. 10.



Phenomena in the right-hand semicircle, northern hemisphere.

[9] This manœuvre is still more important in a spiral storm, especially if the ship be in the left-hand semicircle, where the winds are mostly blowing directly towards the centre.

in the *right-hand* semicircle of a cyclone in the *northern hemisphere* the wind hauls *with* the sun, whether in a rotatory, incurving, or spiral storm.

Wind hauls with the sun.

Phenomena in the left-hand semicircle, northern hemisphere.

22. The phenomena in the left-hand semicircle of a rotatory or incurving storm will be exactly the reverse of those in the right hand, inasmuch as the hauling of the wind will be in the contrary direction; taking the passage of the ship as the line W.—S., fig. 10, the changes of the wind will be N., N.N.W., N.W., increasing in force; N.W., W.N.W., W., decreasing in force. Here we find the hauling of the wind to be contrary to or against the course of the sun, and from a like induction of numerous individual cases, the general principle is deduced, that in the *left-hand* semicircle of a cyclone in the *northern hemisphere*, the wind hauls *against* the sun.[10]

Wind hauls against the sun.

[10] In a spiral storm, in the Northern hemisphere, while the hauling of the wind in the left-hand semicircle is against the sun, the changes are much more extensive than in either a rotatory or an incurving storm. The following tables exhibit the changes in both semicircles, according as the storm is advancing N.W., N., or N.E.

TABLE III.

Right-hand Semicircle.

Anterior Quadrant. Wind Increasing.				Posterior Quadrant. Wind Decreasing.		
N.W.	E.N.E.	E.		E.S.E.	S.E.	S. by E.
N.	E. E.S.E.	S.E.	S.S.E.	S.S.E.	S.	S.S.W.
N.E.	S.E.	S.S.E.	S.	S.W.	W.S.W.	

TABLE IV.

Left-hand Semicircle.

Anterior Quadrant. Wind Increasing.				Posterior Quadrant. Wind Decreasing.		
N.W.	N.N.E.	N.	W.	S.W.	S.	
N.	E.N.E.	N.E. N.	N.W.	N.W.	W.	W.S.W.
N.E.	E.S.E.	E.N.E.	N.	N.W.	W.N.W.	W.

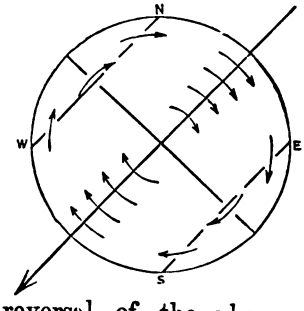
From these tables in connection with fig. 4, it will be readily seen that the changes of the wind are more numerous and rapid on a line parallel with the axis-line in the anterior than in the posterior semicircle. It is, however, important for commanders of homeward-bound vessels from America to note particularly the character of *westerly* winds which they may experience; increasing force of wind, with a rapidly falling barometer, will announce to them that they are in the posterior quadrant of the left-hand semicircle of a spiral

23. It is highly important that a distinction should be made here between *the rotation of the air* IN *the hurricane* and the *hauling of the wind* arising from the progressive and revolving motions combined. Many nautical men have considered that "the law of storms" has no foundation, because they have remarked that the wind has changed or hauled in accordance with the apparent course of the sun; and as the "law" says distinctly the rotation is contrary to the course of the sun, they have imagined that the hauling of the wind must be in the same direction. The rotation of the air is one thing, and its results as a matter of experience is another. In the northern hemisphere, as we have already observed, the rotation is *always contrary to the course of the sun;* but the hauling of the wind resulting from this rotation, combined with the progressive motion, is *only contrary to the course of the sun when the ship is in the left-hand semicircle,* unless under circumstances hereafter to be noticed.

Liability of mistaking the hauling of the wind for the rotation in the hurricane.

24. It cannot be too much impressed on the minds of nautical men that, with certain exceptions, the characteristic phenomena of storms are *reversed in the opposite hemispheres.* These exceptions are the rotation of the air in the cyclone being *always* contrary to the apparent course of the sun, and the motion of the entire body of air in rotation being *obliquely from the equator towards the poles.* It is simply the reversal of the apparent course of the sun in the heavens that occasions the reversal of the phenomena

Fig. 11.



storm, moving towards the north-east, and carrying them to the centre, and not on the southern margin or radius of a circular or incurving storm, which would be fair for their voyage.

Phenomena in the right-hand semicircle, southern hemisphere.

observed or experienced. Accordingly, in the right-hand semicircle of a southern storm, the hauling of the wind is contrary to the course of the sun. A ship on the line W.—N., fig. 11, in a circular storm, experiences the following changes: S., S.S.W., S.W., wind increasing in force; S.W., W.S.W., W., wind decreasing in force. The course of the sun is exactly the reverse.

Wind hauls against the sun.

Phenomena in the left-hand semicircle, southern hemisphere.

25. In like manner, the hauling of the wind in the left-hand semicircle of a southern circular storm coincides with the apparent course of the sun. A ship on the line S.—E., fig. 11, has E., E.N.E., and N.E., winds increasing in force; and N.E., N.N.E., and N., winds decreasing in force; this is at once seen to be in accordance with the motion of the sun in the southern hemisphere—he is observed to rise in the east, culminate in the *north*, and set in the west.

Wind hauls with the sun.

26. From the above instances and reasonings, the following general rules are deducible :—

General rules.

THAT IN THE NORTHERN HEMISPHERE THE HAULING OF THE WIND IN THE *right-hand semicircle* OF A CIRCULAR, INCURVING OR SPIRAL STORM, WILL COINCIDE *with* THE APPARENT COURSE OF THE SUN, WHILE IN THE *left-hand semicircle* IT IS *against* THE APPARENT COURSE OF THE SUN.

Northern Hemisphere.

Southern Hemisphere.

THAT IN THE SOUTHERN HEMISPHERE THE HAULING OF THE WIND IN THE *right-hand semicircle* IS *contrary to* THE APPARENT COURSE OF THE SUN, BUT *coincides with it* IN THE *left-hand semicircle.*

Phenomena when the motions of a ship and hurricane are inclined to each other, the ship moving faster than the hurricane.

These rules have reference more particularly to a ship either lying-to or making but little way on her course during the progress of a hurricane, and are the *legitimate deductions* from the rotatory and progressive motions of storms. It may, however, occur, that the course of a vessel may be such, that, upon combining the three—*i.e.*, the rotation of the storm, its progressive motion, and the course of

the ship, as in section 20—the hauling of the wind may be that of the *opposite* semicircle—the left-hand, for instance, instead of the right-hand—while the ship is in the right-hand semicircle in the northern hemisphere, and the converse in the southern. For this, nothing more is requisite than that the velocity of the ship should be greater than that of the hurricane. In this case, the hauling of the wind in the right-hand semicircle in the northern hemisphere will be *against*, instead of *with* the sun: the same change will hold good in the southern hemisphere, the wind hauling *against*, instead of *with* the sun in the left-hand semicircle.

If the case alluded to in section 20 was fraught with difficulty, as indicating a hurricane course very different from the true one, the case now under consideration—by no means unlikely, especially near the neighbourhoods of recurvature wherever this phenomena may happen — is, if possible, beset with greater difficulties; for, while there can be no doubt on the commander's mind relative to the bearing of the centre or margin of the gale from his ship, as determined by the direction of the wind *at the time*, unless he experiences winds in accordance with those given in Tables III. and IV., on page 20. In such a case, he may conclude that he is in a spiral storm, and this will increase his doubt as to the direction of the motion and velocity of the hurricane, *when combined with the ship's motion;* for, while he attends *only* to the veering of the wind, he is very likely to find himself greatly in error.

The simple hauling of the wind, under the circumstances mentioned, indicates the position of the vessel *to be exactly the reverse of the true—i. e.*, with regard to the semicircle of the storm; and, although the bearings of the centre will be the same whether the ship be in the right or left-hand semicircle, yet the conclusions the commander may draw as to the direction in which the storm may be progressing may be very erroneous. He cannot, however, in any case, be

very far out in apprehending his *approach to the centre* from increasing bad weather, with a falling barometer. Knowing the probable bearing of the centre, although ignorant of the nature of the cyclone and the direction in which it may be moving, he cannot possibly do wrong in putting his ship at right-angles to the wind, on the starboard tack in the northern, and on the port tack in the southern hemisphere, so that the centre may bear aft of his vessel. This course will speedily *reverse* the hauling of the wind, raise his barometer, remove him from the violent portion of the storm, and, in whatever direction the cyclone may be moving, greatly assist him in avoiding its fury. (See figs. 5 and 6.)

Application of the Combined Results of the Progressive, Rotatory, Incurving, and Spiral Motions of Storms.

27. The above deductions and general rules are capable of an extensive application, especially in the determination of the positions of vessels in a hurricane. Each storm-path in the northern hemisphere is directed, generally speaking, towards one of the following points—the N.W., N., or N.E.; while in the southern hemisphere, the points to which the hurricane may advance are S.W., S., or S.E. A cyclone advancing towards any one of these points exhibits certain changes of the wind in the right and left-hand semicircles. We shall consider these changes in the order which is enumerated above.

From the remarks in paragraphs 20 and 26, it will easily be understood that the following instances have reference to ships placed in such circumstances as the undermentioned:

Circumstances under which the following remarks are applicable.

—When hove-to, or sailing with a velocity less than that with which the hurricane is moving, either in the same direction or approaching the axis-line at any angle; or when crossing the cyclone in the opposite direction to which it is progressing, or sailing into it at any angle. The

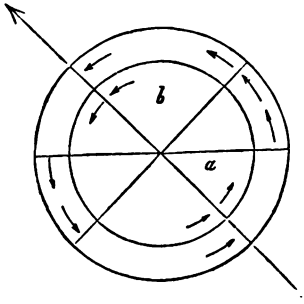
only instances in which a commander will experience a different veering of the wind are, as before shewn, when his velocity is greater than that of the cyclone, and he is sailing parallel to, or his course is inclined to or from, the axis-line. A very little consideration will shew him that, if he experience a different veering of the wind from that which he has reason to expect in the locality in which he may be sailing, it will always be accompanied with increasing bad weather, a falling barometer, and other indications of his approaching the centre of the cyclone.

NORTHERN HEMISPHERE.

HURRICANE moving towards the N.W. SHIP in the right-hand semicircle.

28. A ship in the right-hand semicircle of a cyclone, moving towards the N.W., will experience winds varying from N.E. by E. to S.E. *increasing* in force, and winds varying from S.E. to S.W. by S. *decreasing* in force. (See fig. 12.) The hauling of these winds will be *with* the sun, so that a commander experiencing a wind from N.E. by E., which continues some time without veering, and then hauls to E.N.E., may be sure that he is in the right-hand semicircle, not far from the axis-line, and that the storm is moving towards the N.W.

Fig. 12.



Hurricane moving N.W., ship in right-hand semicircle.

In a spiral storm, as soon as the wind veers to E.S.E., it begins to decrease in force, the barometer rising at the same time; and as in neither instance of a storm moving N. or N.E. an E.S.E. wind decreases in force, this wind veering to S.E. indicates the presence of a spiral storm. The following table gives the radial winds and bearings of centre of Ley and Meldrum storms moving N.W.

TABLE V.

Rad.	Winds. Ley.	Mel.	Bearing of Centre. Ley. Pts.	Mel. Pts.
N.	E. by N.	E.N.E.	9	10
N.E.	S.E. by E.	E.S.E.	9	10
E.	S. by E.	S.E.	9	12
S.E.	S.W.	S.	8	12
S.	W.	S.S.W.	8	14
S.W.	N.W. by W.	W.	9	12
W.	N. by W.	N.	9	8
N.W.	N.N.E.	N.E.	10	8

HURRICANE moving towards the N.W. SHIP in the left-hand semicircle.

Hurricane moving N.W., ship in left-hand semicircle.

29. A ship in the left-hand semicircle of a cyclone, moving towards the N.W., will experience winds varying from N.E. by N. to N.W. *increasing* in force, and winds varying from N.W. to S.W. by W. *decreasing* in force. (See fig. 12.) The hauling of these winds will be *against* the sun, so that a commander experiencing a wind from N.E. by N., which continues some time without veering, and then hauls to N.N.E., may conclude that the ship is in the left-hand semicircle, not far from the axis-line, and that the storm is moving towards the N.W.

In a spiral storm, as soon as the wind has backed to W., which by the way would carry a ship, running before it, to the centre of the storm, its force begins to decrease, and the barometer begins to rise; the further hauling of the wind to S.W., and ultimately to S., as the hurricane passes over the ship—were she hove-to—with decreasing force and rising barometer, is characteristic of a spiral storm.

Hanging winds with increase of force.

*** In the present state of our knowledge respecting storms, a commander, finding a N.E. by E. or N.E. by N. wind *to hang*, while it increased in force, would not wait for its hauling, he would at once conclude that the ship was either on or not far from the axis-line, and take his measures accordingly. This remark will apply to all *hanging* winds not far

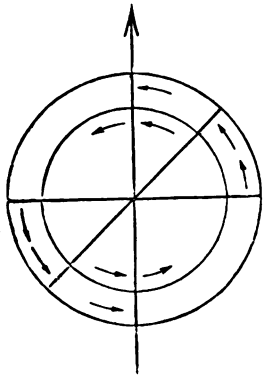
removed from the axis-line. It must, however, be clearly understood, that if the hanging wind be *not* accompanied by an *increase* of force, the indication is that the ship and centre of the storm are moving on parallel courses; a very different state of things, requiring different measures for extrication. For hanging winds, under other and different circumstances, see section 20.

Without increase of force.

HURRICANE moving towards the N. SHIP in the right-hand semicircle.

30. A ship in the right-hand semicircle of a cyclone moving towards the N. will experience winds varying from E. by S. to S. *increasing* in force, and winds varying from S. to W. by S. *decreasing* in force. (See fig. 13.) The hauling of these winds will be *with* the sun, so that a commander experiencing any of them hauling with the sun, will conclude that his ship is in the right-hand semicircle of a cyclone advancing towards the N.

Fig. 13.



Hurricane moving N. ship in right-hand semicircle.

The distinguishing winds of the right-hand semicircle between a north-westerly and northerly course of the hurricane are S.E. to S. These winds *decrease* in force when the cyclone advances towards the N.W., but they increase in force when it moves towards the N. (Compare figs. 12 and 13.)

Distinguishing winds.

The winds which characterize the anterior quadrant of a spiral storm vary from E. to S.S.E. *increasing* in force, while those in the posterior vary from S.S.E. to S.S.W. *decreasing* in force. The distinguishing winds of the right-hand semicircle of a spiral storm are E.S.E. to S.S.E. *decreasing* in force in a storm advancing towards the N.W., and *increasing* in force when the storm advances towards the N.

TABLE VI.

Distinguishing Winds.	Class of Storm.	Course of Storm.
S.E. to S.	Circular.	N.W. dec. N. inc.
E.S.E. to S.S.E.	Spiral.	N.W. dec. N. inc.

The Radial Winds and bearings of centre of Incurving and Spiral Storms moving N. are given in

TABLE VII.

Rad.	Winds. Ley.	Mel.	Bearings of Centre. Ley. Pts.	Mel. Pts.
N.	E.N.E.	E.	10	8
N.E.	S.E. by E.	E.S.E.	9	10
E.	S. by E.	S.S.E.	9	10
S.E.	S.W. by S.	S.	9	12
S.	W.	S.W.	8	12
S.W.	N.W.	W.S.W.	8	14
W.	N. by W.	N.W.	9	12
N.W.	N.E. by N.	N.E.	9	8

For the corresponding table of storms moving N.E., see Table I., foot note [4], p. 11.

Tables I., V., and VII. acquaint us with the LAW that in spiral storms, as propounded by Meldrum, the bearings of the centre vary from eight to fourteen points from the direction of the wind at the ship reckoned *with* the sun as follows:—Taking the anterior radius of the axis-line as zero:—On the *axis-line* and radius *four* points to the left of it reckoned *against* the sun—bearing of centre EIGHT points; on the *eighth* radius, or *eight* points from the axis-line on the left—bearing of centre TWELVE points; on the *twelfth* radius, also on the left—bearing of centre FOURTEEN points; on the *sixteenth* and *twentieth* radii—bearing of centre TWELVE points; and on the *twenty-fourth* and *twenty-eighth* radii—bearing of centre TEN points.

*** From the sixteenth the radii are in the right-hand semicircle.

When a ship steaming or sailing through the left-hand semicircle, parallel with the axis-line, arrives in the neighbourhood of the *twelfth* radius, she will experience winds which change much more rapidly than those of a cyclone.

Under these circumstances, the commander may recognize two conditions, viz., that the centre bears from TWELVE to FOURTEEN points from the wind, and also that the winds he falls in with would by their incurving carry him directly to the centre.

HURRICANE moving towards the N. SHIP in the left-hand semicircle.

31. A ship in the left-hand semicircle of a cyclone moving towards the N. will experience winds varying from E. by N. to N. *increasing* in force, and winds varying from N. to W. by N. *decreasing* in force. The hauling of these winds are *against* the sun, so that a commander may at once conclude that his ship is in the left-hand semicircle of a storm moving towards the north, if he experience any of them hauling *against* the sun.

Hurricane moving N., ship in left-hand semicircle.

The distinguishing winds of the left-hand semicircle between a north-westerly and northerly course, are N. to N.W. These winds *increase* in force when the cyclone advances towards the N.W., but they *decrease* in force when it advances towards the N. (Compare figs. 12 and 13.)

Distinguishing winds.

In a hurricane progressing towards the north, a N.E. wind is found to haul against the sun, or from N.E. to N.

The winds in this semicircle of a spiral storm which increase in force, are those between E.N.E. and N.W., and as they veer to N.W. they draw rapidly towards the centre. This circumstance renders the entire anterior quadrant of the left-hand semicircle dangerous, as compared with the same quadrant of a circular storm: for in the anterior quadrant of the right-hand semicircle of a spiral, scudding brings the ship on the *axis-line*, as in a cyclone; but in the same quadrant of the left-hand semicircle, while carrying it for a short time away from the *axis-line*, scudding brings it directly towards the destructive centre, and finally involves it therein.

In the posterior quadrant of this semicircle the danger is fearfully increased, especially to homeward bound vessels; for although this quadrant is characterized by N.W. to W.S.W. winds, which a commander would naturally take advantage of, they blow directly towards the centre, and great care should be exercised in manœuvring, so as to depart as little from the ordinary track as possible.

A reference to figs. 1 and 4 will at once show the essential difference between *westerly* winds of a circular and spiral storm in the northern, and *easterly* winds of the same kinds of storm in the southern hemisphere; they are *crucial*, and commanders cannot pay too much attention to them, if fallen in with either at the point of recurvature, or when the storm is travelling on a N.E. course in the northern hemisphere, or on a S.W. course in the southern.

The wind distinguishing the left-hand semicircle of a spiral storm, as it advances towards the N.W. or N., is *westerly*, which increases in force when the storm is travelling towards the N.W., but decreases in force as its course is directed northerly.

TABLE VIII.

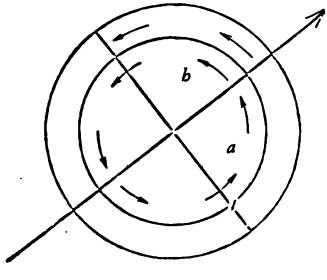
Distinguishing Winds.	Class of Storm.	Course of Storm.
N. to N.W.	Circular.	N.W. inc. N. dec.
W.	Spiral.	N.W. inc. N. dec.

HURRICANE moving towards the N.E. Ship in the right-hand semicircle.

Hurricane moving N.E., ship in right-hand semicircle.

32. A ship in the right-hand semicircle of a cyclone, moving towards N.E., will experience winds varying from S.E. by S. to S.W. *increasing* in force, and winds varying from S.W. to N.W. by W. *decreasing* in force. These winds are found to haul *with* the sun.

Fig. 14.



Upon comparing figures 12 and 14, it will be remarked that

the winds of the *first* segment of the right-hand semicircle in a storm advancing towards the N.E., viz., S.E. by S. to S.W. (see segment *a*, fig. 14), characterized the *second* segment of the same semicircle of a cyclone advancing towards the N.W. (see segment *a*, fig. 12). In the case of the storm moving towards the N.W., when the ship experiences these winds with *decreasing* force, *the hurricane is passing off;* but in the case of a storm advancing towards the N.E., the same winds are distinguished by an *increase* of force, and they are felt more or less at the *commencement* of a storm. These facts furnish an important general rule.

S.E. by S to S.W. winds distinguishing different courses of a cyclone.

WHEN A SHIP IN THE NORTHERN HEMISPHERE EXPERIENCES WINDS BETWEEN THE S.E. AND S.W. POINTS, INCLUDING THE S., AT THE *commencement* OF A STORM, *and they increase in force, hauling with the sun,* THE SHIP IS IN THE RIGHT-HAND SEMICIRCLE OF A STORM, MOVING EITHER TO THE NORTH OR NORTH-EAST;—TO THE NORTH IF, AFTER THE WIND HAS HAULED TO THE S., IT *decreases* IN FORCE; AND TO THE N.E. IF IT CONTINUE TO *increase* IN FORCE AFTER HAVING PASSED THE S. POINT. [11]

General Rule.

*** If these winds do not appear until after those between N.E. and S.E., including E., have been experienced (thus forming tail winds), the cyclone is moving towards the N.W.

If a vessel meet with a S.E. by S. wind, which hangs a considerable time before hauling, the commander would conclude he is on or near the axis-line; but the same phenomenon would occur to a ship sailing into the north-eastern verge of a cyclone *shortly before its arriving at the point of recurvature.* (See sections 20 and 26.) In this case the

[11] This rule requires but little modification to adapt it to a spiral storm travelling N. or N.E., the winds of the anterior quadrant being between E. and S., those of the posterior between S.S.E. and W.S.W., including both cases. See Table, foot note [10], p. 20.

velocity of the cyclone being slackened, and the ship getting in advance of it with a *fair* wind for her voyage, would so gradually, and at last rapidly near the axis-line, that she would have to lie-to in perhaps the most dangerous part of the storm. The remarks in section 20 will apply here, and we shall have occasion to direct attention to the same subject in a subsequent part of the work.

HURRICANE moving towards the N.E. SHIP in the left-hand semicircle.

Hurricane moving N.E., ship in left-hand semicircle.

33. A ship in the left-hand semicircle of a cyclone moving towards the N.E., will experience winds varying from S.E. by E. to N.E. *increasing* in force, and winds varying from N.E. to N.W. by N. *decreasing* in force. These winds haul against the sun.

A ship in the left-hand semicircle of a spiral storm, travelling towards the N.E., experiences winds varying from E.S.E. to N. increasing in force, which are rapidly succeeded by westerly winds drawing directly to the centre of the storm. The winds characterizing the whole of the left-hand semicircle differ so considerably from those of a cyclone, that a homeward bound commander, overtaken by the left-hand semicircle of a spiral storm, can very soon ascertain his position by the different hauling of the wind.

It will be seen, on comparing figs. 12 and 14, that the winds on the *northern margin* of the storm are very differently affected, according as the hurricanes are moving towards the N.W. or N.E. These winds are N.E. by E. to S.E. In a cyclone moving towards the N.W., they are right-hand semicircle, or, to use a sea phrase, "starboard" winds, increasing in force and hauling *with* the sun. In a hurricane moving towards the N.E., they are left-hand semicircle, or "port" winds, also increasing in force, but hauling *against* the sun. These winds may consequently be considered test winds, as

Test winds.

determining, by their hauling *with* or *against* the sun, the direction in which the hurricane is moving. We have accordingly the following general rule. (See segments *b b*, figs. 12 and 14.)

General Rule.

WHEN A SHIP IN THE NORTHERN HEMISPHERE EXPERIENCES WINDS BETWEEN THE S.E. AND N.E. POINTS, INCLUDING E., AT THE COMMENCEMENT OF A STORM, AND THEY HAUL *with* THE SUN, THE SHIP IS IN *the right-hand semicircle* OF A STORM *advancing towards the N.W.*; BUT IF THEY HAUL *against* THE SUN, THE SHIP IS IN *the left-hand semicircle* OF A STORM *advancing towards the N.E.* [12]

Hanging winds.

If in either of the above cases the winds between E.N.E. and E.S.E. hang, especially the E., the storm is advancing towards the north.

Westerly hurricane winds.

34. A further deduction, and one that may probably be found of considerable importance in familiarising seamen with the character of hurricane winds, is, that a *westerly* wind is seldom if ever experienced as an initial wind, or met with at the commencement of a cyclone. A consideration of figures 7, 10, 11, and 13, will lead to the conclusion that westerly winds occur only in the latter portions of circular storms, and when experienced, they are always found to *decrease* in force. Fig. 7 exhibits the important fact, that westerly hurricane winds, in both hemispheres, always characterise the margins of storms next or towards the equator; and as the storms always move from the equator towards

[12] It will be seen from the table in foot note [10], p. 20, that the winds of a spiral storm which haul *with* the sun, as it advances towards the N.W., are E.N.E. to S. by E. Of these the E.S.E. to E.N.E. are the only winds that occur in the left-hand semicircle hauling *against* the sun, as the storm travels towards the N.E. As a general rule, from winds between the E.N.E. and S. points, hauling *with* the sun but *decreasing* in force, upon the E.S.E. wind being experienced the commander may conclude that he is overtaken by the right-hand semicircle of a spiral advancing N.W.; but if he experiences E.S.E. to E.N.E. winds, hauling *against* the sun and *increasing* in force, he may conclude that he is in the anterior quadrant of the left-hand semicircle of a spiral advancing N.E.

the poles, those winds toward the equator must necessarily be found in posterior portions of the cyclone.

There is, however, an *apparent* exception to any rule that may be founded on these phenomena. A vessel from India, crossing the equator, may sail into the northerly semicircle of a southern storm, and experience fresh gales from the westward, *increasing* in force as the commander plunges more deeply into the heart of the hurricane; and to him these phenomena would have the appearance of the *commencement* of a cyclone with westerly winds; the difference, however, between their being initial or terminal phenomena, would immediately become apparent on his heaving to—the storm would gradually leave him.

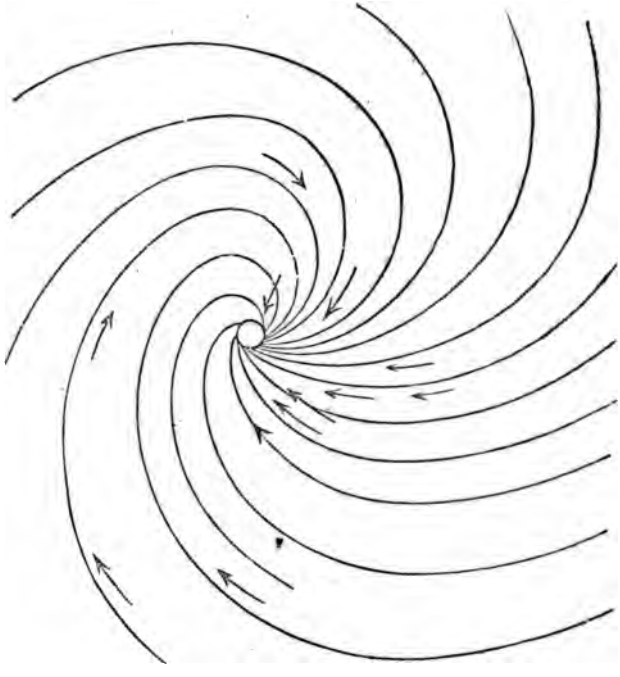
There is another case in which a westerly wind of hurricane force would appear as an initial wind; it is when a commander homeward bound from America plunges into the posterior quadrant of the left-hand semicircle of a spiral storm in advance of him. A little carrying on will soon acquaint him that he is not on the southern margin of a cyclone.

Application of the combined Results of the Progressive and Rotatory Motions of Cyclones to Storms in the

SOUTHERN HEMISPHERE.

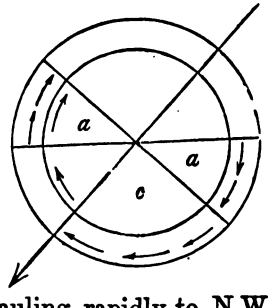
35. Before we proceed to contrast the phenomena arising from Cyclones, Incurving and Spiral Storms, we shall reproduce Mr. Meldrum's diagram of the storm of the 25th of February 1860, fig. 15: in which the arrows indicate the winds, as reported from the ships involved. With a very slight but immaterial alteration from the original, this diagram exhibits a very marked *incurvature* towards the centre, and is strikingly in contrast with the whirl in the southern hemisphere. See fig. 2.

Fig. 15.



HURRICANE moving towards the S.W. SHIP in the right-hand semicircle.

Fig. 16.



Hurricane moving S.W., ship in right-hand semicircle.

36. A ship in the right-hand semicircle of a cyclone moving towards the S.W. experiences winds varying from S.E. by S. to S.W. *increasing* in force, and winds varying from S.W. to N.W. by W. *decreasing* in force. These winds are found to haul *against* the sun.

The winds of the right-hand semicircle of a spiral storm are S.S.W., hauling rapidly to N.W. as the ship approaches the centre. Were she hove-to not far from the axis-line, as the posterior quadrant passes her,

the winds experienced are N.W., N., and N.N.E. decreasing in force.[13]

Upon referring to section 32, it will be seen that the winds experienced in the *right-hand semicircle of a southern storm moving towards the S.W.* are precisely similar to the winds characterising the *right-hand semicircle of a northern storm moving towards the N.E.*, but instead of hauling with the sun, as in the northern hemisphere, they are found to haul contrary to his apparent course. That this should be the case as regards cyclones is perfectly clear from the consideration that the rotation and direction of motion being reversed, the same winds must be found in the same semicircles; but as the apparent course of the sun is opposite in opposite hemispheres, the hauling of the wind, *though exhibiting the same succession in both cases*, when referred to the points of the compass, is of an opposite character when referred to the apparent course of the sun.[14]

[13] The following are the corresponding tables for the Southern hemisphere, to Tables III. and IV. for the Northern, in foot note [10], p. 20.

TABLE IX.

Right hand Semicircle.

Anterior Quadrant. Wind Increasing.		Posterior Quadrant. Wind Decreasing.		
S.W.	S.S.W.	N.W.	N.	N.N.E.
S.	S.E.	S.W.	W.	N.W.
S.E.	E.S.E.	S.	S.W.	W.

TABLE X.

Left-hand Semicircle.

Anterior Quadrant. Wind Increasing.	Posterior Quadrant. Wind Decreasing.				
S.W.	S.E.	E. by S.	E.	N.E.	
S.	E.	N.E.	N.N.E.	N. by E.	N.	N.W.
S.E.	N.E.	N.E. by N.	N.N.E.	N.	N.W.	W.

[14] Instead of the winds characterising the right-hand semicircle of a Southern spiral advancing to the S.W., being similar to those in the right-hand semicircle of a Northern spiral advancing to the N.E., they differ as under:—

TABLE XI.

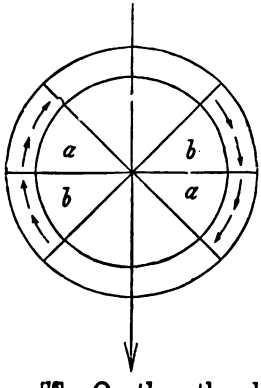
Wind Increasing.				Wind Decreasing.		
N.E.	S.E.	S.S.E.	S.	S.W.	W.S.W.	
S.W.		S.S.W.		N.W.	N.	N.N.E.

HURRICANE moving towards the S.W. SHIP in the left-hand semicircle.

37. A ship in the left-hand semicircle of a cyclone moving towards the S.W. experiences winds varying from S.E. by E. to N.E. *increasing* in force, and winds varying from N.E. to N.W. by N. *decreasing* in force. These winds, of course, are similar to the left-hand semicircle or "port" winds of a northern storm moving towards the N.E., but instead of their hauling *against*, they haul *with* the sun.[15] Hurricane moving S.W., ship in left-hand semicircle.

HURRICANE moving towards the S. SHIP in the right-hand semicircle.

Fig. 17.



38. From what has already been advanced relative to southern storms, the reader will be quite prepared for the announcement of the winds that characterise the right and left-hand semicircles of a cyclone moving towards the S. in the southern hemisphere. Section 30 informs us that the winds of the right-hand semicircle are E. by S. to S. *increasing* in force, and S. to W. by S. *decreasing* in force, but hauling *against* the sun.[16] On the other hand, in a Hurricane moving S, ship in right-hand semicircle.

[15] The winds of the left-hand semicircle of a Southern spiral advancing to the S.W. differ from those of a similar storm in the Northern hemisphere moving towards the N.E. as under :—

TABLE XII.

	Wind Increasing.				Wind Decreasing.		
N.E.	E.S.E.	E.	N.E.	N.	N.W.	W.N.W.	W.
S.W.		S.E.			E. by S.	E.	N.E.

[16] Winds of spirals, Northern and Southern hemispheres :-

TABLE XIII.

	Wind Increasing.				Wind Decreasing.		
N.	E.	E.S.E.	S.E.	S.S.E.	S.S.E.	S.	S.S.W.
S.			S.E.		S.W.	W.	N.W.

HURRICANE moving towards the S., with the SHIP in the left-hand semicircle—

Hurricane moving S., ship in left-hand semicircle.

The winds vary from E. by N. to N. *increasing* in force, and N. to W. by N. *decreasing* in force; they haul *with* the sun.[17]

Distinguishing winds.

39. The distinguishing winds of cyclones moving towards S.W. and S. in the southern hemisphere, are S. to S.W. in the right-hand, and N. to N.E. in the left-hand semicircle. The S. and S.W. winds *increase* in force as the hurricane proceeds towards the S.W., but *decrease* in force as it progresses towards the S.; on the contrary, the N. and N.E. winds exhibit precisely the opposite phenomena of *decreasing* in force when the cyclone moves towards the S.W., and *increasing* when it moves towards the S. (See segments *aa aa*, figs. 16 and 17.)

HURRICANE moving towards the S.E. SHIP in the right-hand semicircle.

Hurricane moving S.E., ship in right-hand semicircle.

40. Upon referring to section 28, we find these winds to be N.E. by E. to S.E. *increasing* in force, and S.E. to S.W. by S. *decreasing* in force; they haul *against* the sun.[18] In the case of a

HURRICANE moving towards the S.E., the SHIP being in the left-hand semicircle—

[17] Winds of spirals, Northern and Southern hemispheres :—

TABLE XIV.

Wind Increasing.					Wind Decreasing.				
N.	E.N.E.	N.E.	N.	N.W.	N.W.	W.	W.S.W.		
S.		E.			N.E.	N.N.E.	N. by E.	N.	N.W.

[18] Winds of spirals, Northern and Southern hemispheres :—

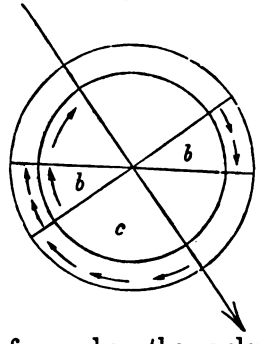
TABLE XV.

Wind Increasing.			Wind Decreasing.		
N.W.	E.N.E.	E.	E.S.E.	S.E.	S. by E.
S.E.	E.S.E.		S.	S.W.	W.

The winds with *increasing* force are N.E. by N. to N.W., and with *decreasing* force N.W. to S.W. by W. These haul *with* the sun.[19] Hurrican moving S.E., ship in left-hand semicircle.

41. The distinguishing winds of cyclones moving towards S. and S.E. in the southern hemisphere, are S.E. to S. in the right-hand, and N. to N.W. in the left-hand semicircle. The S.E. and S. winds *increase* in force as the hurricane proceeds towards the S., but *decrease* in force as it progresses towards the S.E. On the contrary, the N. to N.W. winds *increase* in force when the cyclone moves towards the S.E., but *decrease* in force when it moves towards the S. (See segments *bb bb*, figs. 17 and 18.)

Fig. 18.



Distinguishing winds.

42. The remarks offered in sections 32 and 33, relative to the advancing and receding segments of storms and test winds, will equally apply to southern storms moving towards the S.W. and S.E. The winds from S.E. by S. to S.W. are found in the advancing segment of a cyclone moving towards the S.W.—of course their force will be *increasing;* but in a storm advancing towards the S.E., these same winds occur in the receding segment with decreasing force, and furnish data for a general rule of a similar character to that in section 32 for the southern hemisphere. S.E by S. to S.W. winds.

WHEN A SHIP IN THE SOUTHERN HEMISPHERE EXPERIENCES WINDS BETWEEN THE S.E. AND S.W. POINTS, INCLUDING THE S., AT THE *commencement* OF A STORM, *and they increase in force, hauling against the sun,* THE SHIP IS IN THE RIGHT- General Rule.

[19] Winds of spirals, Northern and Southern hemispheres :—

TABLE XVI.

Wind Increasing.				Wind Decreasing.			
N.W.	N.N.E.	N.	W.	S.W.	S.		
S.E.	N.E.			N.E. by N.	N.N.E.	N.	N.W.W.

HAND SEMICIRCLE OF A STORM MOVING EITHER TO THE S.W. OR S. TO THE S.W. IF, AFTER THE WIND HAS HAULED TO THE S., IT CONTINUE TO *increase* IN FORCE; BUT THE HURRICANE MOVES TO THE SOUTH IF THE WIND *decreases* IN FORCE AFTER IT HAS PASSED THE S. POINT.

*** If these winds do not appear until after those between N.E. and S.E., including E., have been experienced (thus forming tail winds), the cyclone is moving towards the S.E.

It will be remarked that these winds are similarly affected in the cyclones moving in the *opposite* directions in the northern hemisphere, with the exception of their hauling; in the northern hemisphere they haul *with*, in the southern *against*, the sun.

Test winds. 43. The test winds are also the same in both hemispheres, viz., N.E. by E. to S.E. In a cyclone moving towards the S.W., they are left-hand semicircle or "port" winds, increasing in force, and hauling *with* the sun; they are also found in the most dangerous quadrant; while in a cyclone moving towards the S.E., they are right-hand semicircle or "starboard" winds, also increasing in force, but hauling *against* the sun. (See segments *c c*, figs. 16 and 18.)

General Rule. WHEN A SHIP IN THE SOUTHERN HEMISPHERE EXPERIENCES WINDS BETWEEN THE S.E. AND N.E. POINTS, INCLUDING E., AT THE COMMENCEMENT OF A STORM, AND THEY HAUL *with* THE SUN, THE SHIP IS IN *the left-hand semicircle* OF A STORM, *advancing towards the S.W.*; BUT IF THEY HAUL *against* THE SUN, THE SHIP IS IN THE *right-hand semicircle* OF A STORM *advancing towards the S.E.*

DIVISION OF STORM AREA.

44. The above considerations lead to a most important division of the storm area. We have already seen this area

divided into quadrants by the natural phenomena exhibited in each: the semicircle on either side the axis-line being characterised by different haulings of the wind, and the semicircles determined by a line transverse to the axis-line, and intersecting it at the centre, being characterised by increasing and decreasing forces of wind (see figs. 19 and 20). If a ship be put before the wind in the *advancing* quadrant of the *left-hand* semicircle in the northern hemisphere, as in fig. 21, she will *sail away from the axis-line*, and will con-

Fig. 19.

NORTHERN HEMISPHERE.

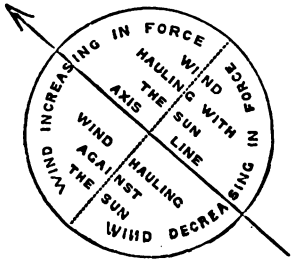
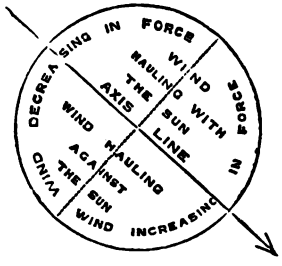


Fig. 20.

SOUTHERN HEMISPHERE.



sequently be removed from the danger of the centre bearing down upon her; but if she be put before the wind in the *advancing* quadrant of the *right-hand* semicircle, she will *sail immediately upon* the axis-line, and may under such circumstances meet the centre. This quadrant has consequently received the name of the *most dangerous quadrant* of the cyclone. In either of the remaining quadrants, a ship may very readily extricate herself from the influence of the hurricane, provided she has plenty of sea-room.

Ship sailing from or to the axis-line or centre.

45. The reversal of the phenonema in the northern and southern hemispheres occasions a reversal of the most dangerous quadrants, so far as the right and left-hand semicircles are concerned. We have just seen that in the northern hemisphere the most dangerous is the advancing quadrant

Fig. 21.

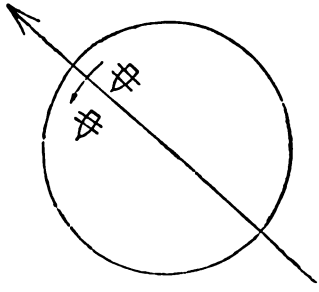
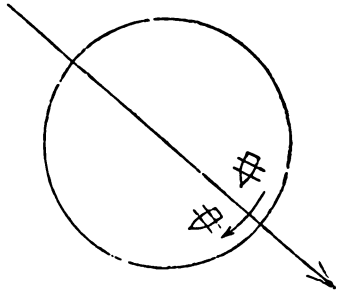


Fig. 22.



of the *right-hand semicircle.* In the southern hemisphere it is the advancing quadrant of the *left-hand semicircle* that is the most dangerous, as shewn in fig. 22, where the vessel put before the wind in the *right-hand* semicircle will *sail away* from the axis-line, but the vessel in the *left-hand* semicircle will *sail upon it.* We have consequently the following important general rule :—

General Rule.

THAT IN THE *northern* HEMISPHERE THE MOST DANGEROUS QUADRANT OF A CYCLONE IS THE *advancing* QUADRANT OF THE *right-hand semicircle;* BUT IN THE *southern* HEMISPHERE IT IS THE *advancing* QUADRANT OF THE *left-hand semicircle.*[20]

[20] This rule applies only to circular or incurving storms ; to meet the case of spiral storms it must be so considerably modified as to include the whole of the left-hand semicircle, as well as the advancing quadrant of the right-hand semicircle in the Northern, and that of the left-hand semicircle in the Southern. In the first place, the winds of the advancing quadrant of the *right-hand* semicircle of a Northern spiral, whether the progression be directed towards N.W., N., or N.E., will carry the ship as in a cyclone towards the axis-line ; also, in a Southern spiral, moving S.W., S., or S.E., the winds of the advancing quadrant of the *left-hand* semicircle will carry the ship towards the axis-line. These winds, as distinguished from those of cyclones, may be ascertained by consulting tables in foot notes [10] p. 20, and [13] p. 36.

In the second place, the incurvature becomes very decided both in the anterior quadrant of the left-hand and in the posterior quadrant of the right-hand semicircles, carrying the ship in either quadrant rapidly to the centre, although should a commander experience the winds characterising the anterior quadrant of the left-hand semicircle, they would at first carry him away from the axis-line.

In the third place, the winds of the posterior quadrant of the left-hand semicircle are more or less directed towards the centre; therefore, from a consideration

CLASSIFICATION OF HURRICANE WINDS.

46. The foregoing remarks under the head of "Application of the Combined Results of the Progressive and Rotatory Motions of Cyclones," lead to the important conclusion, that a classification of hurricane winds may be of very valuable assistance to the seaman; and we have been thus minute in specifying *all* the phenomena arising from the two motions of cyclones, as well as of spirals, so far as our present knowledge will allow, that the resulting classification may be of the most available character in announcing the presence of a hurricane.

Westerly winds.

47. One prominent feature of the northern and southern cyclones is a class of winds characterising the *margins and radii directed towards the equator*. These, we have seen, are westerly winds, and the quadrant embracing those from N.W. to S.W., including West, is in a great majority of instances a *receding* quadrant, *i.e.*, westerly winds are mostly found towards the close of a storm.[21]

48. As the westerly winds are mostly found at the close of a storm, so the easterly winds are characteristic of the com-

of these results of an incurvature as suggested by Meldrum, it follows that by far the most dangerous quadrant of a spiral storm is the posterior of the left-hand semicircle. This does not, however, invalidate the dangerous character of the advancing quadrant of the right-hand semicircle in the Northern, and the left-hand semicircle in the Southern hemisphere, but rather renders it necessary that a commander should hesitate before attempting to cross the axis-line, as suggested in the former edition of this work.

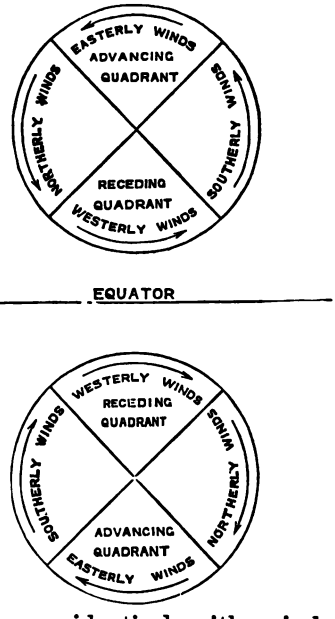
It cannot be too much impressed upon seamen that while the most dangerous is the anterior quadrant of the right-hand semicircle of a Northern cyclone, the anterior quadrant of the left-hand semicircle being the most dangerous of a Southern cyclone, the most dangerous quadrant of a spiral is the posterior of the left-hand semicircle in both hemispheres; for, according to Meldrum's diagram, the winds in the posterior quadrant curve directly towards the centre, and a ship put before any of them would quickly find the vortex. Spiral storms are therefore far more dangerous than circular storms, inasmuch as in these storms one quadrant only exceeds in danger, but in spiral storms the entire left-hand semicircle is much more dangerous than the right.

[21] Westerly winds also characterise the left-hand semicircles of spirals moving towards the N.E. in the Northern hemisphere. See foot note [10], p. 20.

mencement of a hurricane. Those from N.E. to S.E. claim the special regard of the seaman, not only from their occurrence in an advancing quadrant of the cyclone, but also from the circumstance that both in the northern and southern hemispheres they are found in the most dangerous quadrant when the storms are moving towards the N.W. and S.W., or in the earlier portions of their respective courses; and this is the more important, as the winds in both cases upon the axis-line are identical with winds characterising the localities in which the storms occur, viz., a N.E. in the N.E. trade, and a S.E. in the S.E. trade. Consequently, the slightest difference in either of these winds (the N.E. and S.E. trades), their blowing fresher than ordinary, accompanied by other phenomena of which we shall speak hereafter, ought not, on any account, to be overlooked; the least change in the character of these winds in the localities above-named are extremely significant, and fully entitle them to be ranked as the most dangerous of the hurricane winds. We have already alluded to their importance as *test* winds. (See sections 33 and 43.)

Easterly winds the most dangerous.

Fig. 23.



Northerly winds.

49. The northerly winds are mostly found as left-hand semicircle or "port" winds in both hemispheres. In the northern hemisphere they characterise the advancing quadrant of the left-hand semicircle in the earlier portion of the *course* of the cyclone, or when it is moving towards the

N.W. (see fig. 12); but in the southern hemisphere they are initial winds in the latter portion, or when the hurricane is moving towards the S.E. (See fig. 18.) Under this phase they claim particular attention, because they occur in the most dangerous quadrant of the hurricane. when the most dangerous.

50. The southerly winds are mostly found as right-hand semicircle or "starboard" winds in both hemispheres. In the southern hemisphere they characterise the advancing quadrant of the right-hand semicircle in the earlier portion of the course of the cyclone, or when it is moving towards the S.W. (see fig. 16); but in the northern hemisphere they are initial winds in the latter portion, or when the hurricane is moving towards the N.E., and here they come in for their share of particular regard as occurring in the most dangerous quadrant. (See section 32, and fig. 14.) Southerly winds, when the most dangerous.

51. Distinguishing winds. These are winds that determine whether a hurricane be moving in a certain direction by their increasing or decreasing in force; they are particularly specified both in the northern and southern hemispheres. (See sections 30, 31, 32, 39, and 41.) Distinguishing winds.

52. Hanging winds. These are so denominated, because a ship, when in a hurricane, may experience *the same wind* for a considerable length of time. Instead of the brisk changes mostly observed, the wind hangs in one quarter. There are three kinds of hanging winds, those resulting from the ship being and remaining on the axis-line; those resulting from the ship sailing towards the axis-line, in the right or left-hand semicircle, according as she is in the northern or southern hemisphere, with a velocity slightly greater than that of the cyclone; and those resulting from the ship sailing parallel with the course of the storm. For the difference between the first two, see section 20, and fig. 9. The difference between the first and last is of easy determination. A hanging wind resulting from the centre of a storm bearing down on the ship is always accompanied by a considerable Hanging winds, of three kinds.

increase in the force of the wind, while the direction and force remains the *same* when the ship sails parallel with the storm.

Marginal winds.

53. Marginal winds are those characterising the margins of storms; they are identical with the radial winds of the same semicircles. (See figs. 1 and 2.)

Radial winds.

54. Radial winds are those blowing on the radii of a storm. They always characterise the same radii in the same hemisphere. (See figs. 1 and 2.)

Test winds.

55. Test winds. These are winds that determine whether a hurricane be moving in a certain direction, by their hauling *with* or *against* the sun. They always blow from points between N.E. and S.E., including E., and are particularly specified in sections 33 and 43.

Tail winds.

56. Tail winds are those that characterise the receding semicircles of revolving storms. They mostly blow from points between N.W. and S.W., including W., and may frequently be employed with advantage.

Practical Results of the Discussion of the Phenomena resulting from the Twofold Motion of Cyclones.

57. Our remarks have hitherto been confined to the phenomena resulting from the twofold motion of a hurricane. It may not, however, be inappropriate in this place to introduce a very important deduction, not so much of a scientific as of a highly practical nature. It is the side on which a vessel will receive the wind in a hurricane, according as she is sailing towards the *centre* or *margin*. In the northern hemisphere, when sailing from the centre to the margin, the ship receives the wind on the starboard side; but if she be sailing from the margin to the centre, or, in other words, getting further into the fury of the storm, she receives the wind on the port side. In the southern hemisphere, as in all the phenomena *resulting* from the reversal of the sun's

Sides on which a vessel will receive the hurricane winds.

apparent course in the heavens, these conditions are reversed; the vessel receives the wind on her *port* side when *sailing*

Fig. 24.
NORTHERN HEMISPHERE.

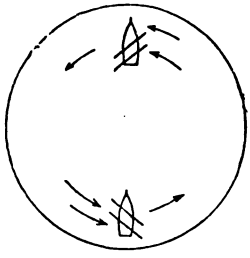
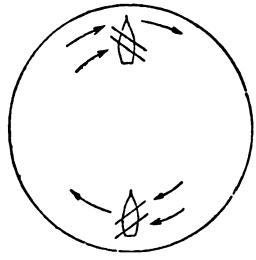


Fig. 25.
SOUTHERN HEMISPHERE.



out of, but on her *starboard* when *sailing into*, a hurricane. (See figs. 24 and 25.)

From these considerations we may deduce the following very general rules, which are perfectly applicable, independently of the direction or hauling of the wind, but, when combined with these phenomena, will be found of very considerable value.

General Rule. Northern Hemisphere.

IF IN THE NORTHERN HEMISPHERE A VESSEL OVERTAKEN BY A CYCLONE, AN INCURVING OR SPIRAL STORM, AND RECEIVES THE WIND ON HER *port* SIDE, HER HEAD IS DIRECTED *to*, AND SHE IS SAILING *towards*, THE CENTRE OR VORTEX; BUT IF SHE RECEIVE THE WIND ON HER *starboard* SIDE, HER HEAD IS DIRECTED *from* THE CENTRE OR VORTEX, AND SHE IS SAILING *out of* THE STORM.

General Rule. Southern Hemisphere.

IF IN THE SOUTHERN HEMISPHERE A VESSEL BE OVERTAKEN BY A CYCLONE, AN INCURVING OR SPIRAL STORM, AND SHE RECEIVES THE WIND ON HER *starboard* SIDE, HER HEAD IS DIRECTED *to*, AND SHE IS SAILING *towards*, THE CENTRE OR VORTEX; BUT IF SHE RECEIVE THE WIND ON HER *port* SIDE, HER HEAD IS DIRECTED *from* THE CENTRE OR VORTEX, AND SHE IS SAILING *out of* THE STORM.

General rules for lying-to.

58. Should the proximity of land, or other considerations, determine the commander to lie-to, the following general rules are immediately deducible from the foregoing:—

Northern hemisphere.

IN THE *northern* HEMISPHERE, BRING THE SHIP TO THE WIND ON THE *starboard* TACK.

Southern hemisphere.

IN THE *southern* HEMISPHERE, BRING THE SHIP TO THE WIND ON THE *port* TACK.

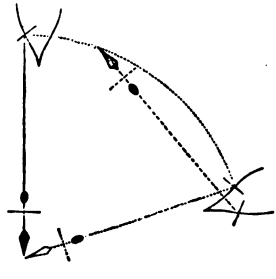
Mooring Ships in Revolving Storms.

59. If the commander consider it desirable to moor his vessel, the foregoing deductions from the rotatory and progressive motions of storms furnish another very important practical result, viz., the side of a ship on which the anchor should be first let go. A very little consideration will shew that this must differ according as the vessel is in the right or left-hand semicircle, and must be determined by her swinging in consequence of the rotation of the whirlstorm. If in the right-hand semicircle in the northern hemisphere, she be moored by a single anchor from the port bow, she will swing in the opposite direction to the wind, and will constantly change her position as the wind veers; and if, afterwards, her starboard anchor be let go, she will be moored in such a way that her cables will not foul, and she will ride with open hawse.

Side of a ship on which the anchor should be dropped first, to prevent fouling her cables.

60. We have seen (section 21) that in the right-hand semicircle in the northern hemisphere the wind hauls with the sun, and, as a consequence, a ship moored by a single anchor will swing with the sun, her head to the wind. Fig. 26 shews that if, under these circumstances, at any point on the arc of the circle on which she swings, the port anchor be dropped *after* the starboard, her further swinging will

Fig. 26.



Circumstances under which cables are crossed.

cross her cables, because she is drifting with her port bow in advance. In the left-hand semicircle she drifts against the sun, of course her starboard bow advancing, and the conditions necessary for the cables crossing are reversed.

Port bow advancing as a ship swings.

61. If a ship swing when moored, from N. to E., or *in the same direction as the hands of a watch move,* in either hemisphere, her port bow will advance, being succeeded by her starboard bow; but if she swing from N. to W., or *in a contrary direction to that in which the hands of a watch move,* in either hemisphere, her starboard bow will advance, being succeeded by her port bow.

Starboard bow advancing.

Port bow advances in the right-hand semicircle in the northern hemisphere.

62. The course of the sun in the northern hemisphere being in accordance with the direction of the hands of a watch, and the wind in the right-hand semicircle, hauling *with* the sun, we find from the last paragraph that in the right-hand semicircle, in the northern hemisphere, the port bow advances as the ship swings, because she drifts in the same direction as the wind hauls; and also, that in the left-hand semicircle the starboard bow advances, because, while she drifts in the same direction as the wind hauls, that direction is *against* the sun, or contrary to that in which the hands of a watch move.

and the starboard bow in the left-hand semicircle.

63. The course of the sun in the southern hemisphere being contrary to the direction in which the hands of a watch move, and the wind in the right-hand semicircle hauling *against* the sun, we also find from the same paragraph, that in the right-hand semicircle in the southern hemisphere, the port bow advances as the ship swings, because she drifts in the same direction as the wind hauls, viz., as the hands of a watch move; and also, that in the left-hand semicircle the starboard bow advances, because, while she drifts in the same direction as the wind hauls, that direction is *with* the sun, or contrary to that in which the hands of a watch move.

Similar phenomena in the southern hemisphere.

From these considerations it follows—

GENERAL RULE. THAT FOR SHIPS TO RIDE WITH OPEN HAWSE IN A REVOLVING STORM, INCURVING OR SPIRAL, THE ANCHOR ON THE *advancing* BOW SHOULD BE DROPPED FIRST. This may be regarded as a very general rule, applicable to all circumstances.

Why the port bow advances in the right-hand semicircles, and the starboard in the left.

64. It is easy to perceive that the port bow advancing by the ship's swing in the right-hand semicircle in both hemispheres, is simply dependent on the hauling of the wind, which is precisely the same in the right and left-hand semicircles, in both hemispheres, *when referred to the motion of the hands of a watch*, although the order of rotation is reversed. By virtue of the progressive motion, the semicircles occupy opposite sides of the storms in the two hemispheres.

GENERAL RULE.

65. It may be desirable in this instance to frame the following general rules, indicating the particular anchor to be dropped first in either the right or left-hand semicircles:—

RIGHT-HAND SEMICIRCLE. A SHIP IN THE RIGHT-HAND SEMICIRCLE OF A STORM, EITHER IN THE NORTHERN OR SOUTHERN HEMISPHERE, IN THE ACT OF MOORING, SHOULD FIRST DROP THE PORT ANCHOR, AND AFTERWARDS THE STARBOARD, IN ORDER THAT SHE MAY RIDE AT OPEN HAWSE.

LEFT-HAND SEMICIRCLE. A SHIP IN THE LEFT-HAND SEMICIRCLE OF A STORM, EITHER IN THE NORTHERN OR SOUTHERN HEMISPHERE, IN THE ACT OF MOORING, SHOULD FIRST DROP THE STARBOARD ANCHOR, AND AFTERWARDS THE PORT, IN ORDER THAT SHE MAY RIDE AT OPEN HAWSE.

*** It is to be understood that the above rules are only applicable to ships swinging at anchor by the effect of the wind. If they drift by a current, resort must be had to the former rule.

CHAPTER III.

BAROMETRIC PHENOMENA CHARACTERISING STORMS.*

66. The effect of the rotative or spiral motion of hurricanes is to produce an accumulation of air *around* the circumference or margin,—in fact, to give the cyclone such a character as we find a cylindrical mass of water assumes when it is put into a state of rapid rotation. The water is thrown up against the sides of the containing vessel, so that a considerable depression exists in the centre; and in the same way we have a considerable depression in the centre of a hurricane, as in the annexed figure.

Fig. 27.

67. If we suppose a barometer to be placed anywhere within the circumference of a cyclone, an incurving or spiral storm, it will exhibit the pressure of the atmosphere dependent on the depression arising from the rotatory, incurving or spiral motions, or, if just exterior to the circumference or margin, the pressure arising from the accumulation of air forming the margin. We have consequently an *increase* of pressure outwards from the centre to the circumference, the lowest barometer occurring in the centre,† and the highest just beyond the margin,

* Great care should be exercised in choosing a barometer for marine purposes, and by all means the commander should have it well compared both before leaving his port and after his return, so that its "set" may be accurately ascertained. For further remarks on the barometer, its position on shipboard, mode of observation, &c., the reader may consult the author's *Hurricane Guide*. The sympiesometer is a valuable instrument on account of its extreme delicacy.

† There is reason to believe that the centre of barometric depression does not coincide with the *true* centre of the hurricane, but is rather in advance of it. As, however, the main object of our work is to endeavour to assist the seaman in avoiding the centre generally, and, indeed, a space of at least fifty miles around it, we may, for all practical purposes, consider the phenomena as stated in the text.

or rather under it; the extreme differences amounting in some cases to two inches and a half. This arrangement of the air above the cyclone renders the barometer not only an admirable and important instrument, but also a faithful monitor in these disastrous storms. We shall therefore solicit the attention of the seaman to its leading phenomena.

The barometer a useful and valuable instrument in storms.

68. It is highly probable that, just as a vessel may be approaching a cyclone, an incurving or a spiral storm, the barometer may be observed to rise. This is the natural result of the margin of accumulated air around the storm. Should this rise of the glass not be observed, it is perhaps the more important to note all the circumstances of its non-appearance, as they are greatly calculated to throw considerable light on other interesting movements of the atmosphere at present but imperfectly understood. On the other hand, should it be noticed—the glass, for instance, standing *much higher than the mean of the locality in which the ship is sailing*—attention should be directed to it immediately.

Barometer higher before the commencement of a cyclone.

69. In accordance with the remarks in the last paragraph the initial barometric phenomena of cyclones, incurving or spiral storms, may be classed under two heads—an extraordinary rise of the mercurial column, and an altitude corresponding with the usual pressure of the locality. Shortly after either of these states of the barometer has occurred, and as the ship is plunging into the vortex, the glass falls very rapidly, and continues to fall until one-half of the storm has passed; and it rises as rapidly during the progress of the remaining half. From these phenomena the following important general rules are deducible:—

Sudden and considerable fall of the barometer.

GENERAL RULES.

THAT IF THE BAROMETER STAND UNUSUALLY HIGH, IT IS VERY PROBABLE A CYCLONE, AN INCURVING OR SPIRAL STORM, IS APPROACHING THE SHIP.

First half of storm.

THAT IF THE BAROMETER, EITHER WITH OR WITHOUT A PREVIOUS RISE, FALL SUDDENLY AND RAPIDLY, THE WIND INCREASING IN FORCE, AND OTHER INDICATIONS OF A CYCLONE, INCURVING OR SPIRAL STORM, BE PRESENT, THE FIRST HALF OF A HURRICANE IS PASSING OVER THE SHIP.

Latter half of storm.

THAT IF THE BAROMETER, AFTER HAVING FALLEN CONSIDERABLY, RISE AT FIRST RAPIDLY AND THEN GRADUALLY, THE LATTER HALF OF THE HURRICANE IS PASSING.

70. The above rules contain the *general* enunciation of the barometric phenomena of storms. Instances have, however, occurred in which the fall has not been so great as the succeeding rise, but no instance can be found on record of a cyclone existing without a depression of the barometer. As a further guide to the mariner, in judging of important and critical storm phenomena, it may be desirable to specify the hurricane winds that are accompanied with rising and falling barometers, according to the direction in which the storm may be moving.

Northern storms moving N.W.

Northern storms moving towards the N.W. have a falling barometer with *northerly* and *easterly* winds (see sections 48 and 49, also fig. 23), and a rising barometer with *southerly* and *westerly* winds. (See sections 47 and 50, also fig. 23.)

Northern storms moving N.E.

Northern storms moving towards the N.E. have a falling barometer with *easterly* and *southerly* winds, and a rising barometer with *northerly* and *westerly* winds. (See fig. 23.)

Southern storms moving S.W.

Southern storms moving towards the S.W. have a falling barometer with *easterly* and *southerly* winds, and a rising barometer with *northerly* and *westerly* winds. (See fig. 23.)

It will be remarked that these phenomena are precisely similar to those characterising northern storms moving in the opposite direction, viz., towards the N.E.

Southern storms S.E.

Southern storms moving towards the S.E. have a falling barometer with *easterly* and *northerly* winds, and a rising barometer with *southerly* and *westerly* winds (see fig. 23). These winds and barometric phenomena are precisely similar to the phenomena and winds characterising northern storms moving in the opposite direction, viz., to the N.W.

*** It will be apparent, from the foregoing statements, that in either of the storm courses mentioned, *easterly* winds are accompanied by *falling* barometers, and *westerly* winds by *rising* barometers, except in incurving storms moving towards the N.E.; in them *westerly* winds blow directly towards the vortex, and are accompanied with a rapidly falling barometer; see foot note [10], on p. 20.

The above rules and remarks have reference only to a ship lying-to in a hurricane, for it is clear that a commander, by sailing from or to the centre, will reverse the phenomena in the several quadrants. By sailing *from* the centre the barometer will *rise*, or by sailing *to* the centre it will *fall*; his object, of course, will be *to keep the barometer well up*, and thus to save his masts and yards.

71. The falling and rising of the barometer, according as the ship approaches to or recedes from the centre, furnish important criteria as to how the commander should act under peculiar and embarrassing circumstances. In sections 20 and 26, allusion has been made to certain phenomena of precisely the same character, presented under very different conditions; in section 26, it is indicated that, upon finding bad weather to increase, and the barometer to fall, the commander cannot well do wrong in putting the ship's head at right angles to the wind, so that the centre may bear aft of his vessel; this will improve his weather, and bring up his barometer; and, in section 20, a lying-to for a short time is recommended, to ascertain if the ship be on the axis-line, or on any radius inclined to it. In the great majority of instances, these manœuvres will be found sufficient to

improve the ship's position in the cyclone; there is, however, one case in which they *fail;* it is when the ship is sailing on the axis-line in advance of the centre, with a velocity less than that of the cyclone. A ship hove-to on the axis-line in advance of the centre, will find that her bad weather increases, and that her barometer falls: then, if she put her head at right angles to the wind, the centre bearing aft, she will either find the weather to improve, and the barometer to rise, or otherwise, according as she may be sailing faster or slower than the hurricane advances. If the bad weather increases, and the wind does not veer, it is highly probable she is on the axis-line, and the proper manœuvre appears to be to edge away to the *left-hand* margin in the *northern*, and the *right-hand* margin in the *southern* hemisphere.

Instances in which certain manœuvres may fail.

The following example will perhaps place these phenomena in an unmistakeable light. A vessel with an easterly course falls in with a hurricane wind from S.E. by E., and is close hauled with her head N.E. by E., in order that she may keep her course as nearly as possible; while doing so, her bad weather increases, her barometer falls, she has to shorten sail, and the wind *veers to S.E.*, indicating her position in the cyclone to be in the *right-hand semicircle, and in the most dangerous quadrant.* From these considerations the commander is induced to round-to, especially as a N.E. by E. course—particularly in the earlier portion of the path of the hurricane—would soon extricate him. Upon his doing so, he finds no advantage to result; the wind is still S.E., the barometer still falls, the bad weather still increases, and the most probable conclusion that he can arrive at is, that when the cyclone overtook him he was in the *left-hand semicircle,* that the storm was moving towards the N.E., and that he has, by pursuing the N.E. by E. course, come upon the axis-line. Not wishing to go far out of his course, he puts the ship's head to N.E., *i.e., at right angles to the wind,* hoping that her velocity may be greater than

Example of failure.

that of the hurricane when sailing directly in advance of its centre, and that he may obtain a position whereby he may be able to edge away to the *eastward*, in advance of the right-hand semicircle. He, however, finds this course to be futile; his falling barometer, his still increasing bad weather, his hanging wind, all tend to convince him that he is not only on the axis-line, but that the cyclone is bearing down upon him with greater rapidity than he can possibly advance, and that his only course is to edge away to the *left-hand margin*, in order to round-to, and allow the centre of the cyclone to pass at a safe distance.

Commanders are solicited particularly to study sections 20, 26, and 71, as affording instances of storm phenomena differing very essentially in their character from such as form the material of "GENERAL RULES." They present to the seaman's mind "*exceptions*," and are calculated to shew that, although the wind, by its hauling, &c., may indicate a state of things very different from the true one, yet there are means to be adopted by which the commander may ascertain his true position, the "*exceptions*" being fully explained by the motions of the cyclone, combined with the ship's course.

CHAPTER IV.

PHENOMENA OF RECURVATURE AND HURRICANE PATHS.

Phenomena of Recurving—Storm-paths of the Northern Atlantic—Their apparent Connexion with the Verticality of the Sun—Probability of their originating in or near the Tropical Zone of Variable Winds—Storm-paths of the Bay of Bengal—Their probable connexion with the N.W. Monsoon—Storm-paths of the Indian Ocean—Probability of their Origin in the same Monsoon—Storm-paths of the China Sea.

72. THE reader will be prepared, from the remarks in Chapter II., to enter on the consideration of one of the most important portions of the track of a cyclone. We have in that chapter specified three directions of progressive motion. Intermediate between the first and last portions of the path, the hurricanes are found to move in the northern hemisphere towards the north, and in the southern hemisphere towards the south; and while the cyclones are thus moving (which is but for a short time), they may be said to be in a state of *transition* between the N.W. or S.W. and N.E. or S.E. branches of the storm-paths in each hemisphere; and, in order to distinguish this part of their course, it has received the very characteristic appellation of the point of recurvature.

Point of recurvature.

73. There is no part of the path of a cyclone presenting occasion for more difficult manœuvring, nor attended with greater danger, than the points of recurvature, with perhaps the exception of the contemporaneous existence of two gales in the same neighbourhood, to which attention will be solicited in a subsequent chapter. In sections 33, 43, and 52, we have endeavoured to point out the great importance of certain winds characterised as test and hanging winds, and it is only by a close and unremitting watchfulness, when the vessel experiences these winds, that the general course of the hurricane may be determined. It is very usual to con-

Latitudes of recurvature variable.

sider that the points of recurvature are, to a certain extent, *stable* in each hemisphere, and the parallels of 30° north and south have been regarded as the latitudes of recurvature, the paths in the lower latitudes being directed towards the N.W. and S.W. respectively, and those in the higher latitudes towards the N.E. and S.E. These conditions do not, however, exist without numerous exceptions, as we shall have occasion to point out; and it therefore becomes very important that commanders should be furnished with accurate data to determine points of recurvature whenever and wherever they occur.

74. The most important of all the hurricane winds for this especial purpose are those which have been termed test winds. These, we have seen, are N.E. to S.E., including E., and charac-

Fig. 28.

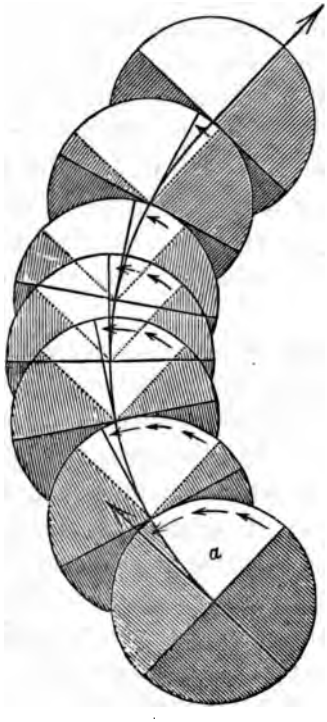
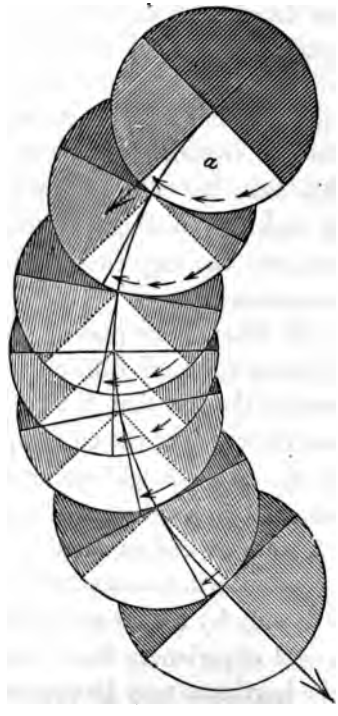


Fig. 29.



terise the most dangerous quadrants as the storms move towards the N.W. and S.W. in either hemisphere. (See quadrants *a a* in figs. 28 and 29.) The commander will consequently keep a sharp look-out on these winds, particularly those between the N.E. and E. points, as in the course of recurving the hurricanes will so move that they will more or less *hang*, especially as the cyclones approach the northern and recede from the southern directions.* The accompanying figures will render these remarks much more intelligible than the most lengthened description. In fig. 28, the winds of the advancing quadrant of the right-hand semicircle (*a*) are gradually seen to be transferred to the left-hand semicircle; and as the hurricane recurves and takes up its north-eastern direction, those particular winds which are likely to hang as the transition occurs, are readily recognised, being *northward* of east *before*, and *southward* of east *after* recurving.

Hanging winds in recurvatures.

Hanging winds before and after recurvature. Northern hemisphere.

75. In the southern hemisphere, by virtue of the reversal of the sun's course in the heavens, and the consequent reversal of certain phenomena of cyclones, the winds that are likely to hang, as the hurricane changes its course from S.W. to S.E., are on opposite sides of the east point as compared with those in the northern hemisphere. In fig. 29, it will be seen that the hanging winds are *south* of the east point in the *first* part of the hurricane's course, and *north* of the east point in the second. We have, accordingly, the following general rules:—

Opposite hanging winds before and after recurvature. Southern hemisphere.

IF A SHIP BE NEAR THE AXIS-LINE OF A HURRICANE IN THE NORTHERN HEMISPHERE, WHICH IS ABOUT TO RECURVE, THE WINDS BETWEEN THE N.E. AND E. ARE OBSERVED TO HANG; BUT IF THOSE SOUTH OF THE EAST POINT, VIZ., BETWEEN E. AND S.E., HANG, THEN THE HURRICANE HAS

General rules. Northern hemisphere.

* In the earlier part of the hurricane's course in the southern hemisphere, the S.E. and E. points should be particularly watched by the commander. Rosser, in his "Law of Storms Considered Practically," gives, on p. 60, a letter from the late Captain Douglas, harbour-master at Port Louis in 1872, to Mr. Meldrum, Secretary of the Mauritius Meteorological Society, in which the captain calls attention to a N.E. wind *converging* towards the centre of a spiral storm.

RECURVED, AND IS GRADUALLY DIRECTING ITS COURSE TOWARDS THE N.E.

Southern hemisphere.

IF A SHIP BE NEAR THE AXIS-LINE OF A HURRICANE IN THE SOUTHERN HEMISPHERE WHICH IS ABOUT TO RECURVE, THE WINDS BETWEEN THE S.E. AND E. ARE OBSERVED TO HANG; BUT IF THOSE NORTH OF THE EAST POINT, VIZ., BETWEEN E. AND N.E., HANG, THEN THE HURRICANE HAS RECURVED, AND IS GRADUALLY DIRECTING ITS COURSE TOWARDS THE S.E.

STORM PATHS.

THE NORTHERN ATLANTIC OCEAN, WESTERN BASIN.

76. An accurate knowledge of the storm-paths or courses the hurricanes pursue, must at all times be extremely valuable to the commander of a vessel, for, if it can be shewn that cyclones travel over the surface of the ocean in pretty nearly the same general tracks, then it would not be difficult to determine, in any given locality, the character of the hurricane winds a ship would be likely to meet with in that particular region. It is usually considered that the most general course of cyclones is that alluded to in section 16, and upon this assumption the consideration of hurricanes moving towards the N.W. or N.E. is based. A work of the present kind would not, however, be complete, unless we fully entered into this part of the subject, especially as it is fraught with interest of no ordinary character, being greatly calculated to throw very considerable light on the origin of revolving storms.

Stormy area of the Northern Atlantic.

77. The stormy area of the western portion of the northern basin of the Atlantic may be said to be comprised within the parallels of 10 and 50 degrees of north latitude, and 30 and 105 degrees of west longitude. Of this immense area the meridians of 50° and 90° include the greatest number of storm-paths; the points of recurvature occurring about the 80th meridian and the 30th parallel.

78. The general direction of the cyclones, first towards

the N.W., and then towards the N.E., may be regarded as a *type* of their movements, but the commander ought not implicitly to rely upon so general—and certainly, so far as any individual hurricane which he may encounter is concerned, so vague—a statement. If the hanging of certain winds, and their veering upon altering his course, *do not agree with the motion of the hurricane as generally stated,* then he is bound to receive THE TESTIMONY OF THE WINDS THEMSELVES, rather than to depend upon any statements whatever that he may have met with, even to the reversal of the usual course of the cyclone.

Testimony of the winds of more importance than a general statement of storm-paths.

79. In order to convey the most accurate information on this head, especially with regard to the Atlantic, which is so much frequented by our English vessels, we have carefully classified the tracks of twenty-seven hurricanes given by our indefatigable countryman, Colonel Sir William Reid, in his late work, entitled *The Progress of the Development of the Law of Storms.* The result of this classification is included in the following table, which contains nine separate classes of the cyclones of the Northern Atlantic, determined by the direction of their motion; Class 3 conforming in the greatest degree to the general type, viz., a N.W. and N.E. motion, with a recurvature about the 30th parallel.

Classification of hurricanes, Northern Atlantic.

Classification of Hurricanes—Northern Atlantic, Western Basin.

CLASS 1.—Hurricanes of which the earliest branches only have been observed, or, at least, in the course of which no indications have been afforded of their recurvature.

No.	Date.	Latitude of Recurvature.	Longitude of Recurvature.	Longitude of Commencement.	Longitude of Termination.	Remarks.
I.	June 23, 1831			57½°	93½°	Course W.N.W.
V.	Aug. 12, 1835			58	99	„ W.N.W.

CLASS 2.—Hurricane of which the earliest branch and recurvature were observed.

No.	Date.	Latitude of Recurvature.	Longitude of Recurvature.	Longitude of Commencement.	Longitude of Termination.	Remarks.
II.	Aug. 10, 1831, ...	30°	89°	57°	88°	

CLASS 3.—Hurricanes which have described a *regular* course, recurving about thirty and thirty-one degrees of latitude, and exhibiting in their paths *two* well-defined branches.

	Aug. 12, 1837,.....	32°	78½°	53°	54°
VI.	„ 12, 1830,.....	31	81½	58	52
III.	„ 17, 1827,.....	30	76	58	51
IX.	„ 22, 1830,.....	31	73½	65	55
VII.	Sept. 29,* 1830,.....	31	68	58	54

CLASS 4.—Hurricanes which have described a regular course, with their apices or points of recurvature accuminated, and occurring on more southerly parallels.

XXII.	Aug. 16, 1851, ...	27½°	86°	47°	47°
XXI.	„ 22, 1848, ...	27	78	57½	34
XV.	Sept. 27,† 1837,.....	27	97½	78	72

CLASS 5.—Hurricanes deviating from the regular course, as exhibited in Class 3, in the latter branches of their progress, *i.e.*, their directions after recurving being more northerly than those of the hurricanes forming Class 3.

VIII.	Sept. 1, 1821, ...	32°	78°	66°	68°
IV.	„ 3, 1804, ...	31	80½	58	66

* The position of this cyclone was very easterly.
† The position of this cyclone was the most westerly.

CLASS 6.—Hurricanes deviating from the regular course, as exhibited in Class 3, in the earlier branches of their progress, *i.e.*, their direction, when first observed, being about N.N.W.

No.	Date.	Latitude of Recurvature.	Longitude of Recurvature.	Longitude of Commencement.	Longitude of Termination.	Remarks.
	Aug. 17,* 1843,.....			62½°	66°	
	Sept. 8, 1839, ...	35°	65°	45	55	
XIX.	„ 11, 1846, ...	29	71	64	38	
XX.	Oct. 6, 1846,.....	30	83	77	64	

CLASS 7.—Hurricanes of which the latter branches only were observed, forming a class of extraordinary movements, the points of recurvature, *if existing*, being situated on or near the equator, as the result of their peculiar form.

XIII.	Oct. 2, 1842, ...			92	62	
	„ 3, 1780, ...			78½	60	
XIV.	„ 4, 1854, ...			83½	53	

N.B.—A great peculiarity characterised these hurricanes, viz., the more easterly the path the more northerly the direction; thus, the direction of the hurricane of October 3, 1780, was more northerly than No. XIV., and this again was more northerly than No. XIII.

CLASS 8.—Hurricanes of which the latter branches only were observed in much higher latitudes than the cyclones of Class 7; they are all north of 30°.

XVII.	Oct. 3, 1844			86	57	Course E.N.E.
XI.	Nov. 10, 1835, ...			88	64	„ E.N.E.
XVI.	Dec. 13, 1839, ...			91½	53	„ E.N.E.

* Witnessed by Colonel Reid, and supposed by him to have passed over the Bay of Fundy. The small portion of the track observed, leaves it doubtful as to whether it was near its point of recurvature.

CLASS 9.—Hurricanes which, from the singularity of their movements, cannot be classed under either of the above heads.

No.	Date.	Latitude of Recurvature.	Longitude of Recurvature.	Longitude of Commencement	Longitude of Termination.	Remarks.
XII.	July 31, 1837, ...			52½°	86½°	
	Aug. 30, 1842, ...			63	103	Nearly due west.
	Oct. 10, 1847, ...			52½	73	
	Oct. 12,* 1780, ...	23°	71°	58	56	The most southern recurvature.

80.—It will readily be remarked that Class 3 containing only five examples, and one of these exceptional so far as date and position are concerned, the type usually fixed on can hardly be regarded as a general type of the storm-paths of the Atlantic, inasmuch as we have other classes containing nearly the same number of examples; also, four or five hurricanes bear so small a proportion to the entire number twenty-seven, as by no means to constitute the majority conforming to the type. It would therefore appear that this type is not applicable to general cases, but only, as we shall presently see, to a certain season of the year.

Usual type of storm-path not generally applicable.

Class I. 81.—The first class of the preceding table comprises two hurricanes, marked I. and V. on Colonel Reid's map. They include a period of about seven weeks; and it is not a little remarkable that they are nearly the earliest on record, so far as *season* is concerned; and No. I. is the only instance of a hurricane having occurred in June. The recurvatures of these cyclones were not observed, and their courses were nearly parallel.

Class VIII. 82.—As a contrast to this class, we may take the 8th Class, which contains hurricanes observed only in the latter

*The hurricane of October 12, 1780, may, with some degree of propriety, be included in Class 4.

part of their course, in very much higher latitudes than the two in Class 1. These occurred at a much later period of the year, an interval of seven or eight weeks elapsing between the date of the last in Class 1 and the first in Class 8. Their courses were parallel, and forming the same angle with the parallel of recurvature (30°) as the storms of Class 1. It must not, however, be forgotten that the storm of October 3 was simultaneous with the storm marked XIV. in Class 7, with which it appears naturally to range, so far as regards its general features.

Class II.

83.—The hurricane mentioned in Class 2 appears to be nearly of the same nature as those comprising Class 1. The point of recurvature being more easterly, probably allowed of its being observed; with one exception, it is the most westerly of the storms whose recurvatures were matters of observation.

Class III.

84.—Class 3 comprises the most regular hurricanes. With the exception of the last, the period of their occurrence is about the middle of August. From a Chronological Table of the principal hurricanes that have occurred in the West Indies during 150 years, published in Johnston's *Physical Atlas*, it appears that the greatest number occurred in August, so that this month may be regarded as furnishing not only the most regular, but also the greatest number of cyclones.

Cyclones occur mostly in August.

Class IV.

85.—The hurricanes of Class 4 deviate from those in Class 3 only in having more accuminated apices, or points of recurvature. The interval embraced by both classes spreads over a period of about seven weeks.

Class V.

86.—Class 5 includes hurricanes whose northern or latter branches are directed more to the north than any of those mentioned in the preceding classes. If any conclusions may be drawn from only two examples, it would appear that deviations from the usual courses begin to be recognised early in September.

Class VI. 87.—The hurricanes in Class 6 differ from those in Class 5, by exhibiting deviations from the usual course not only in the latter, but also in the former or southern branches of their paths, and these occur at a still later date, the last three examples occupying about a month.

Class VII. 88.—Class 7 contains a collection of very extraordinary cyclones occurring near the beginning of October in three separate years, and commencing in each case nearly on the same parallel. They all agree in exhibiting in *low latitudes* the latter branches *only* of the hurricane paths; and it is not a little remarkable, that as the cyclone has pursued a more easterly track, its direction has been more northerly; this feature appears to be well brought out.

89.—The hurricane of October 6, 1846 (Class 6, XX.), appears to have been first observed not very far from the point at which the cyclone of October 3, 1780, was first encountered. The path of this hurricane (XX.) not only deviates from the usual course of Class 3, but very considerably from the course of the cyclones in Class 7.

Class IX. 90.—We have already alluded to the *later* occurrence of the hurricanes in Class 8, and have only to notice the very anomalous cyclones in Class 9, which at present cannot be included in any particular category, owing to their isolation. The hurricane of July 31, 1837, not in Colonel Reid's chart, but to be found in his *Attempt to Develop*, &c., chart vi., page 57, is very remarkable. Its course at first was due west, it having been most probably encountered at its *formation* by the Judith and Esther; it then proceeded in the usual course to about the 30th parallel, where, instead of *recurving*, it passed over the land in a direction towards the N.W., inclining to W.N.W. It is the only instance of a hurricane moving in the direction of a lower storm branch in so high a latitude. The hurricane of October 10, 1847, is extremely remarkable, as moving *from the pole very*

*obliquely towards the equator** ; it apparently originated in the N.E. trade.

91.—Upon the whole, it would appear, although we should be very unwilling,—especially in a matter of such immense moment, in which the safety of either Her Majesty's vessels or of those in the merchant service is concerned, and upon so slender a comparison as that resulting from twenty-seven instances,—to draw any conclusions, yet, as inducing nautical men themselves to collect information bearing upon this part of the inquiry, and the setting on foot observations that may tend to connect the form of the storm-path with the season of the year—we would remark, that so far as the tracks have been laid down by Col. Reid, it would appear that, as the season advances, certain deviations from a particular form of path, which may be regarded as a type, shew themselves; in point of fact, the type itself is confined to but a few days in the middle of August, a period characterised by the greatest number of cyclones. The early part of the season is distinguished by certain forms of storm-paths in certain localities, while in the latter part other deviations quite as well marked occur in different localities.

Deviations from the typical storm-path earlier and later than August.

92.—The earliest cyclones appear to originate near the equatorial border or limit of the N.E. trade, and to traverse the trade nearly at right angles to the direction of the aerial current—in other words, the north-east wind does not appear to impel the hurricane forward; in fact, so far as we have yet been able to learn, the cyclones generally appear to progress independently of prevailing currents, either oceanic or aerial. The general crowding together of the observed commencements of the storm-paths within the area of 50° and 60° of west longitude, and 10° and 20° north latitude, bears out our remark, not only with regard to the earliest hurricanes, but to the hurricanes generally of the Northern Atlantic, that they originate in or just beyond

Crowding of the storm-paths towards the equatorial limit of the N.E. trade.

* See similar instances, Bay of Bengal and China Sea, pp. 78, 94, and 95.

the equatorial limit of the trade. Such an originating cause appears to exist in the narrow zone of variable winds and calms *always* situated to the north of the equator, and characterised by some very peculiar meteorological features, being the region of least atmospheric pressure, and also of a frequent, indeed almost constant, precipitation of rain, always accompanied by electrical explosions —these features only occurring within the limits of the tropics in this zone, which in the neighbourhood of the cyclones is separated by the northern portion of South America.

Zone of constant precipitation.

93. It is well known that the *verticality* of the sun within the tropics exercises a most wonderful influence on the exhibition of meteorological phenomena. In order to endeavour to indicate the further line of research calculated to throw light on the origin of revolving storms, we have given in the following table the declination of the sun on the day each hurricane specified was encountered within the limits of 10° and 20° north latitude, and 50° and 60° east longitude, one cyclone only excepted.

TABLE XVII.

Hurricanes which probably originated in the equatorial zone of variable winds and calms.

Date.	Class.	Sun's Declination.	Remarks.
June 23, 1831.	1	23½° N.	Sun near the Tropic.
July 31, 1837.	9	18¼ N.	
Aug. 10, 1831.	2	15½ N.	Sun nearly vertical to the locality in which cyclones originate.
„ 12, 1835.	1	15 N.	
„ 12, 1830.	3	15 N.	
„ 12, 1837.	3	15 N.	
„ 17, 1827.	3	13¼ N.	
„ 22, 1848.	4	11½ N.	
Sept. 3, 1804.	5	7½ N.	Sun vertic. to the zone of calms.
„ 8, 1839.	6	5½ N.	
„ 29, 1830.	3	2½ S.	Sun south of the zone of calms.
Oct. 10, 1847.	9	6¾ S.	
„ 12, 1780.	9	7½ S.	

94. This table makes us acquainted with the fact, that while the sun is north of the zone of variables, the cyclones are found in the first four classes—with one exception, *the deviation in this instance occurring about the point of recurvature;*—and the still more important relation, that upon his return from the tropic of Cancer, when he arrives about the parallel of 15° north, the greatest number of cyclones occur, which appear to originate almost immediately under him. The slightest glance at the relations of the rainy seasons to the course of the sun within the tropics, will at once connect the occurrence of the cyclones to *greatest quantity*, with the verticality of the sun as the *rainy season is approaching its close;* and it is to be remarked that these hurricanes conform in the greatest degree to the generally assumed type. While the sun is crossing the zone of variables, the paths of the cyclones deviate from the general type, both in their lower and upper branches; and when the sun is south of the zone of variables, the paths become more or less anomalous.

The most regular cyclones occur when the sun is vertical to the locality of their origin.

Deviations occur when the sun crosses the zone of variables.

95. Out of the small number of 27 hurricanes, one-third were experienced in the months of August and September, or 33 per cent. of the whole number. In section 84, *ante*, p. 65, we find from 150 years' record that the greatest number of cyclones in the Northern Atlantic occur in August. M. Andre Poey, of Havana, has found from records during a period of 363 years,—viz. from 1493 to 1855—that 355 hurricanes were fallen in with, of which 176 occurred in August and September. The monthly distribution is as follows:—

TABLE XVIII.

January	5	·001	July	42	·012
February	7	·002	August	96	·027
March	11	·003	September	80	·023
April	6	·003	October	69	·017
May	5	·001	November	17	·005
June	10	·003	December	7	.002

Taking the average frequency of the hurricanes during the

months of July, August, September, and October, amounting to 287, as ·8, the whole number recorded being 355, the average frequency of the 68 for the remaining 8 months will be nearly ·2, or about one-fourth.

96. Three tracks of cyclones have been traced by Colonel Reid and Mr. Piddington, in the Eastern Atlantic, which appear to have originated on or near the coast of Africa. The points of recurvature were not observed, but there is every reason to believe they existed. These instances are very much to the present point, as a glance at a general rain map will shew that the coast of Africa exhibits the meteorological feature common to all coasts, of precipitating the moisture brought by the indraught of air over the land. The two storm-tracks of Colonel Reid and Mr. Piddington, over the Cape de Verde Islands, indicate a much larger sweep before recurvature than that appertaining to the Madeira hurricane of October 1842.

Cyclones originating west of the Isthmus of Darien.

97. It has been already mentioned that the zone of constant precipitation is separated by the mainland of South America, and there are indications of cyclones originating in or near this zone, *west of the narrow strip of land connecting the two Americas*, and not presenting the phenomenon of recurving. They have been encountered in the Caribbean Sea and Gulf of Mexico, at a time when the sun had two or three degrees' south declination, and the phenomenon of recurving has not been observed in the Western Atlantic in any hurricane that has occurred later than October 12. Two of the cyclones in Class 8 were observed when the sun had great southern declination. Those cyclones that occurred about the same period as the hurricanes whose probable origin we may place westward of the Isthmus, and recurved, commenced to the eastward of the connecting strip of land. Upon a consideration of the whole of the facts illustrated by Table XVII, as well as the general classification of hurricanes which we have attempted, there appears to be a

great probability that the hurricane paths are in some way determined by the verticality or declination of the sun in much the same manner as the rainy and dry seasons.

THE BAY OF BENGAL.

98. Whatever circumstances may operate to determine the courses of storm-tracks, or to modify their direction, when once induced, we find, with the exceptions alluded to in the last division, a general tendency in the cyclones to move in a north-westerly direction, and this is observed in other localities than the basin of the Northern Atlantic. In the Bay of Bengal, where the meteorological conditions are very different, we have tracks varying from W. by S. in its south-west portion, just to the north of Ceylon, to N. by E. in the neighbourhood of Calcutta, without any very decided instances of recurvature. The Bay may be divided into three cyclone portions; the north-eastern, or that portion between the Andamans and the coast from Juggurnath to Chittagong; the central portion, stretching from the north of Sumatra to the coast south-westward of Juggurnath to Masulipatam; and the south-western, from Masulipatam to Cape Comorin. These portions are very distinctly characterised by storm-paths of different directions. While writing this paragraph, I have before me Mr. Piddington's Chart (III.) of the Bay of Bengal, with each storm-path specified by a distinct character, according to the month in which the cyclones occurred. In this map the divisions above named are very striking; the north-eastern being crowded with the paths of storms moving N.N.W., N.W., and W.N.W., with some exceptions hereafter to be noticed; the central being remarkably clear of storm-tracks, three only crossing it in different directions; and the south-western having them moderately scattered, with a direction varying from W. by S. to N.W. From the whole of Mr Piddington's projections, it is clear that each portion of the

Tracks of hurricanes in the Bay of Bengal.

Cyclone divisions of the Bay.

Each division characterised by its storm-tracks.

Bay of Bengal is furnished with its specific storm-paths, so far as direction is concerned; and we cannot rise from the contemplation of Mr Piddington's map, especially in connexion with the storm-tracks of the Atlantic, without being strongly impressed with the idea, that whatever may give rise to rotatory storms, the configuration of land and water, combined with geographical latitude and the influence of season, *determine* in a very great degree the courses they pursue. In common with all great meteorological phenomena, they are affected by these powerful influences; and the more we connect them in our studies, the more we are likely, not only to become further acquainted with their laws, but to render the fresh acquisitions of our knowledge available to purposes of the greatest importance in navigation.

99. Mr Piddington, in speaking of the tracks of the Bengal hurricanes, has this remark: "As yet we do not know if the tracks are influenced by the monsoons, and are thus more inclined to particular routes according to the season of the year; and this is one of many subjects for inquiry." Our inquiry into the storm-paths of the Western Atlantic (sections 76 to 97), very strongly leads to the idea *that hurricanes are influenced by season, not only as to number, but also as to direction*, and there appears to be, to a certain extent, similar indications in Mr Piddington's map. The following table will show the influence of season, as to number, on the storms encountered in the Bay of Bengal; the first division, viz., from March to August, having reference to the S.W. monsoon; and the second, from September to February, to the N.E. monsoon:—

Hurricane paths influenced by season.

SOUTH-WEST MONSOON.*

March.	April.	May.	June.	July.	August.	Total.
1		10	4		1	16

NORTH-EAST MONSOON.

Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total.
	11	8	1	1		21

The sixteen storm-tracks having reference to the S.W. monsoon are disposed over the area of the Bay, as in the following tables, which at once inform us that the storm-paths are more northerly in the higher latitudes, agreeing in this respect with the storm-paths of the Western Atlantic. The month of May, in the north-eastern part of the Bay of Bengal, furnishes the greatest number of cyclones moving towards the N.N.W. There are some anomalies, of which we shall speak hereafter.

SOUTH-WESTERN PORTION.

Direction.	Month.	Year.
E. — W.	March.	1820
E. — W.	May.	1811
E. — W.	...	1843
E.S.E. — W.N.W.	...	1841
S.E. — N.W.	...	1843

CENTRAL PORTION.

Direction.	Month.	Year.
E.N.E. — W.S.W.	May.	1820

* Mr Rosser, in his work already mentioned, (see note, p. 59), quotes Lieut. Col. Gastrell's and Mr H. F. Blanford's work on the Calcutta Cyclone of October 5, 1864, as to the *Probable Law of Cyclones in the Bay of Bengal.* Their general summary includes, under the S.W. monsoon, 3 in April, 3 in May, 2 in July, and 1 in August, extra, but they have one cyclone less for June; under the N.E. monsoon they give one extra in September; 3 in October; and 3 in November; the total number of cyclones in the Bay that have came under the notice of cyclonogists is 53, of which 17 occur at the commencement of the S.W. monsoon, and 25 at its end, when they are most frequent.

NORTH-EASTERN PORTION.

Direction.	Month.	Year.
E. by N. — W. by S.	June.	1839
E.S.E. — W.N.W.	..	1842
S.E. — N.W.	...	1822
S.E. — N.W.	May.	1834
S.S.E. — N.N.W.	...	1823
S.S.E. — N.N.W.	...	1833
S.S.E. — N.N.W.	...	1837*
S.S.E. — N.N.W.	...	1840
S.S.E. — N.N.W.	June.	1842
S. — N.	August.	1835

The twenty-one storm-tracks having reference to the N.E. monsoon are disposed over the area of the Bay as under :—

SOUTH-WEST PORTION.

Direction.	Month.	Year.
E. by N. — W. by S.	November.	1815
E. — W.	October.	1800
E. — W.	...	1836
E. — W.	...	1836
E. — W.	December.	1803
E.S.E. — W.N.W.	November.	1845
E.S.E. — W.N.W.	...	1845
S.E. — N.W.	October.	1818
S.S.E. — N.N.W.	November.	1842
S. — N.	January.	1805

NORTH-EAST PORTION.

Direction.	Month.	Year.
E. — W.	October.	1842
E. by S. — W. by N.	November.	1838
E.S.E. — W.N.W.	October.	1842
E.S.E. — W.N.W.	November.	1839
S.E. — N.W.	October.	1842
S.E. — N.W.	...	1849
S.E. by S. — N.W. by N.	...	1831
S.E. by S. — N.W. by N.	...	1832
S.E. by S. — N.W. by N.	...	1838†
S.E. by S. — N.W. by N.	November.	1839
S.S.E. — N.N.W.	...	1797

* The authority for this cyclone is doubtful.

† The direction of this cyclone was rather more northerly than here indicated

Upon comparing the tables having reference to the south-western monsoon, with those having reference to the north-eastern, we see that at nearly opposite seasons of the year the same conditions relative to the storm-paths obtain, viz.:—That the more northerly the cyclones, the more northerly their directions. There is, however, this important difference, for, on comparing the tracks of the storms during October with those observed in May, it will be seen that the paths of the October hurricanes are directed *more to the west* than those of the May cyclones; this appears to arise from the influence of season.*

The following tables exhibit the months in which hurricanes have been encountered in the Bay of Bengal, the division in which they have been met with, and the course they have pursued.

THE SOUTH-WEST MONSOON.

Month—March.

DIVISION—S.W.

Direction, E. — W. | 1 Hurricane.

Month—May.

DIVISIONS.

SOUTH-WEST.		CENTRAL.		NORTH-EAST.	
Direction.	Hurricanes.	Direction.	Hurricane.	Direction.	Hurricanes.
E.—W.	2	E.N.E.—W.S.W.	1	S.E—N.W.	1
E.S.E.—W.NW.	1			S.S.E.—N.N.W.	4
S.E.—N.W.	1				

* "The cyclones of the extreme south part of the bay tend towards westward rather than northward, because at the period when they principally occur the N.E. monsoon is at its height. * * * Those originating in the north part of the bay progress towards the N.W. and N. by W., because at the period when they occur the S.W. wind is dominant, and it is but slightly affected by the current from the northward."—*Rosser's Law of Storms, p.* 95.

"Cyclone paths diverge from three principal foci. The first, which may be called the northern focus, is a little to the east of the middle of that part of the bay northward of Cape Negrais and the Godavery river: the second or Andaman focus, is in the immediate vicinity of those islands ordinarily a little to the west or N.W. of the group: and the third or southern focus, is at about mid-distance between Ceylon and the Nicobar Islands; [the cyclone paths] discussed in reference to these foci would [favor the conclusion] that at the

Month—June.

DIVISION—N.E.

Direction.	Hurricanes.
E. by N.—W. by S.	1
E.S.E.—W.N.W.	1
S.E.—N.W.	1
S.S.E.—N.N.W.	1

Month—August.

DIVISION—N.E.

Direction, S.—N. | 1 Hurricane.

THE NORTH-EAST MONSOON.

Month—October.

DIVISIONS.

SOUTH-WESTERN.		NORTH-EASTERN.	
Direction.	Hurricanes.	Direction.	Hurricanes.
		E. — W.	1*
E. — W.	3	E.S.E. — W.N.W.	1
S.E. — N.W.	1	S.E. — N.W.	2
		S.E. by S. — N.W. by N.	3

Month—November.

DIVISIONS.

SOUTH-WESTERN.		NORTH-EASTERN.	
Direction.	Hurricanes.	Direction.	Hurricanes.
E. by N. — W. by S.	1	E. by S. — W. by N.	1
E.S.E. — W.N.W.	2	E.S.E. — W.N.W.	1
S.S.E. — N.N.W.	1	S.E. by S. — N.W. by N.	1
		S.S.E. — N.N.W.	1

beginning of the S.W. monsoon, cyclones originate in the south part of the bay rather than in the north, while at the end of the S.W. monsoon they appear first in the north, then at the Andamans, and lastly in the south."—*Rosser's Law of Storms, pp.* 94, 95.

* This hurricane passed from the Andamans across the Indian peninsula, over the Arabian Sea, to the coasts of Arabia; its track is the longest on record in this part of the world. It can hardly be said to belong to the north-eastern division of the Bay of Bengal, as it is common to all the divisions as well as to the Arabian Sea; it is, however, placed here as having taken its rise in the north-eastern division.

Month—December.

DIVISION—S.W.

Direction, E.—W. | 1 Hurricane.

Month—January.

DIVISION—S.W.

Direction, S.—N. | 1 Hurricane.

Utility of the tables of hurricane tracks.

It is apprehended the above tables will be found of great utility in navigating the Bay of Bengal. If the commander meet with a hurricane in any month, he will see under that month *its most probable course*, should a hurricane have been encountered before during that month; if the month has hitherto been blank, he will, of course, do all in his power to ascertain the track of the cyclone; and every such instance sent to the author, through the publishers, will meet with due attention.

Application of the tables of hurricane-tracks.

100. The mode of practically applying these tables is as follows: A commander in the month of May falls in with a hurricane while he is sailing over the south-western part of the Bay. In this division he finds the hurricane routes vary from E.—W. to S.E.—N.W., or four points. It is therefore probable his hurricane is moving between these points, and he will, of course, endeavour to ascertain from the phenomena presented at his ship if the cyclone conform to either of the four hitherto observed. If not, all the information he can obtain relative to it will be enhanced in value, although information relative to cyclones pursuing the usual tracks will still be very valuable. If the commander be sailing over the north-easterly division of the Bay near Calcutta, he will conclude that a S.S.E.—N.N.W. track is the most likely one for his cyclone: any deviation from this he will, of course, most attentively notice, and gather as much information concerning it as he can.

101. The cyclone of June 1839, known as the Sand Heads Cyclone, was moving on an anomalous course, viz., from E. by N. to W. by S. In this respect it resembles the

cyclone of November 1815, also moving on the same course, in the neighbourhood of the north of Ceylon, and the Tobago hurricane of October 1847, in the West Indies. These cyclones were all moving *obliquely from the pole to the equator.*

Cyclones moving obliquely from the pole to the equator.

The only cyclone, that of May 1820 (see table in section 99), which has been *first* encountered in the central portion of the Bay of Bengal, presents a much greater degree of anomaly than either of the preceding; its course, until it impinged on the coast, about a degree and a half north of Madras, was towards W.S.W., *obliquely from the pole towards the equator;* it crossed the Indian peninsula nearly due West.

Remarkable instance of recurvature.

A very remarkable cyclone occurred in November and December 1842; its course appears to have been from about 5° to 10° north latitude N.N.W., and then to have *recurved towards the west,* so that it afterwards described a W.S.W. course, moving *obliquely from the pole towards the equator.*

The cyclone that has presented the greatest anomaly in its course, in this part of the world, is, doubtless, the one common to the Bay of Bengal and the Arabian Sea. Originating a little to the east of the Andamans towards the end of October 1842, instead of following the usual course of the hurricanes in this part of the Bay, it moved nearly due west until its centre passed over Pondicherry; here its course became deflected towards the S.W., and, as it passed over the peninsula, it moved *obliquely from the pole.* When it regained the oceanic surface west of India, its course was again altered, and directed towards W.N.W., until it arrived on the coasts of Arabia. As a striking contrast to this course, we may take that of the Cuttack hurricane in the latter end of April and early part of May 1840; they both appear to have originated not far from the same spot, east of the Andamans, but pursued very different

Path of the Madras hurricane, Oct. 1842.

tracks at opposite seasons of the year, when the meteorological relations of the Bay were very different.

102. In the examination of the Atlantic storm-tracks, we solicited attention to the zone of variable winds, calms, and constant precipitation, accompanied by electrical explosions. In the Indian Ocean, this zone is absent; it here suffers a complete interruption, and is replaced by the monsoons which occupy the entire area of the Indian Ocean, including the Arabian Sea and Bay of Bengal; and it is not a little remarkable, that, at the season when cyclones are most prevalent in the Bay of Bengal, their tracks should usually cross the N.E. monsoon much in the same way as the earlier branches of the West Indian hurricanes cross the N.E. trade. We have hinted at the great probability that most of the cyclones of the Northern Atlantic originate in, or just on the borders of, the zone of precipitation; and the general tracks of the Bengal hurricanes also favour the idea, that the locality in which they originate is the limit of the contemporaneous system of monsoons, blowing in the northern part of the Indian Ocean. Indeed, there is a great similarity betwen the two classes of phenomena—the *West Indian* hurricanes, at a certain season of the year, moving obliquely towards the pole, from the zone in which *active precipitation is taking place*; and the *Bengal* hurricanes also moving much in the same direction from a zone, that of the N.W. monsoon, in which *active precipitation is also taking place.* This monsoon characterises the rainy season in the southern district, while the N.E. monsoon characterises the dry season in the northern district of the monsoon regions.

The equatorial zone of calms interrupted in the Indian Ocean.

The West Indian and Bengal hurricanes originate respectively in or near a zone precipitating aqueous vapour.

103. The preceding remarks have reference to the cyclones occurring in October and November; but, from the table in section 99, we find the month of May, the period of the S.W. monsoon, also furnishing a considerable number of hurricanes. At this season the meteorological relations of the Bay and

Indian Ocean are reversed, *the active precipitation is going on in the region in which the cyclones are formed*, and their tracks cross the monsoon current nearly, but not quite, in the same direction as the N.E. current was crossed. It is worthy of remark that, at the *two* periods when cyclones are prevalent, the sun has similar declination on each side of the equator, being vertical to the upper portion of the Bay in May, and traversing the middle portion of the Indian Ocean in November.

THE ARABIAN SEA.

104. Our information relative to the storm-paths of the Arabian Sea is very scanty; indeed there is some reason to believe that in this locality cyclones but rarely occur. The best authenticated instances appear to indicate a course so nearly parallel with the land, as to coast the western shores of India, a feature discernible in the great majority of hurricanes in the Northern Atlantic.

Tracks of the Arabian Sea influenced by the land,

Mr Piddington gives the tracks of five, varying in direction from N.W. to N.N.W.; he has also recorded one that occurred in April 1847, moving "on shore" with a N.E. by N. direction; and one in October 1842, moving nearly parallel with, but about two degrees north of, the Madras storm of October and November 1842. The latitudes of these tracks extend from $7\frac{1}{2}°$ to 21° north, and, with the exception of the cyclones of October 1842, *the influence of the land forming the western shores of India* is very apparent in determining *the more northerly tracks in lower latitudes*, as compared with the tracks in the Bay of Bengal. The direction of the cyclone of April 1847 would lead to the idea of its having recurved.

and by the seasons.

105. Cyclones occur in the Arabian Sea as in the Bay of Bengal during both monsoons. Rosser gives a table of fifteeen, distributed over the year as follows:—

S.W. Monsoon.	March 1		September..... 1	N.E. Monsoon.
	April..... 2		October..... 1	
	May..... 1		November 5	
	June.. 2		December..... 2	
	6		9	

From this table it appears that hurricanes in the Arabian Sea, as well as in the Bay of Bengal, are connected with *change of monsoon*, and Piddington's Chart shews that those connected with the N.E. monsoon resemble the hurricanes of the Bay of Bengal, not only in being more numerous, but in pursuing much more westerly paths than those connected with the S.W. monsoon.

THE INDIAN OCEAN.

106. The existence of the same conditions, relative to the season as well as the locality of the storms of the Indian Ocean, south of the equator, appears to point to the presence of aqueous vapour in the act of precipitation, as an essential element in the production of a rotatory storm; at least, if the vapour itself be not actually precipitating at the time the storm originates, the general conditions of the atmosphere appear to be such as to characterise the localities above mentioned; and here it would seem we have a connecting link that binds most of the varied phenomena of storms into a beautiful and harmonious whole; we have, in fact, a full explanation of the liability of the commander of a vessel to meet one of these tremendous visitants of the Indian Seas at any point between Madagascar and Australia, by the simple fact that the N.W. monsoon, the rain-producing wind, borders the equatorial limit of the S.E. trade during the season cyclones are prevalent; and it is not at all surprising, from these considerations, that two or even more hurricanes may be found raging at the same time, each having originated on the northern limit of the trade from the precipitation of vapour in the N.W. monsoon. It is even likely that in cer-

Similar conditions relative to the storms of the Indian Ocean indicate that the precipitation of aqueous vapour is essential to the production of storms.

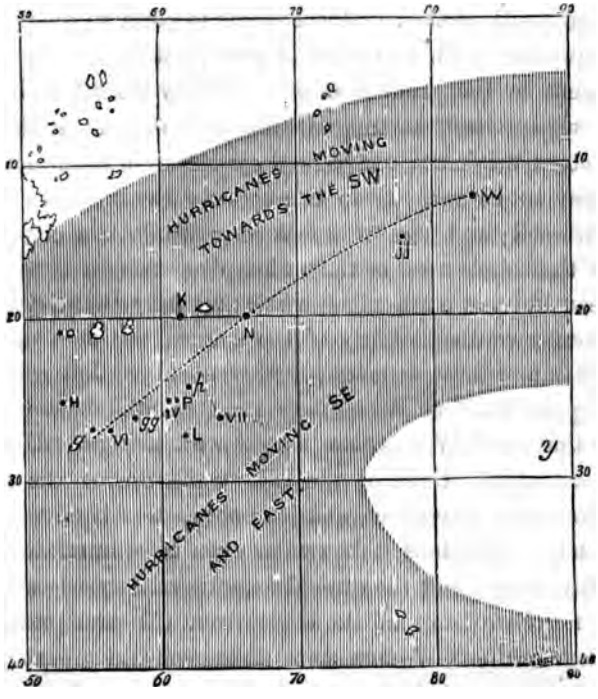
TABLE XIX.

Latitudes and Longitudes of Recurvature.

INDIAN OCEAN.

Mark.	Hurricanes.	Date.	Lat.	Long.	Authority.
W	City of Poonah.	Nov. 1851.	12°30′S.	82°30′E.	Birt.
jj	Maria Somes	Mar. 1846.	15 0 S.	78 0 E.	Piddington.
N		Nov. 1847.	20 0 S.	66 30 E.	Bonsquet.
K		Mar. 1848.	20 0 S.	61 12 E.	...
O	Berceau.	Dec. 1846.	21 0 S.	52 12 E.	...
p	Thos. Grenville.	Jan. 1836.	24 30 S.	61 45 E.	Piddington.
P	Blenheim.	Mar. 1851.	25 0 S.	60 45 E.	Methven.
IV.	Blenheim.	Feb. 1807.	25 0 S.	60 30 E.	Reid.
H		Jan. 1848.	25 15 S.	52 40 E.	Bonsquet.
qq	Windsor.	Feb. 1837.	26 0 S.	58 0 E.	Piddington.
VII	Serpent.	Feb. 1846.	26 30 S.	64 0 E.	...
VI	Culloden.	Mar. 1809.	27 0 S.	56 12 E.	Reid.
q	Thalia.	April 1827.	27 0 S.	55 0 E.	Piddington.
L		Jan. 1848.	27 30 S.	61 45 E.	Bonsquet.

Fig. 30.



tain localities not far removed from land, of an insular character, these revolving storms may come into existence within the monsoon itself; and should the place of its origin be *on the equator*, it is not very difficult to conceive that a *twin* storm may be the result, each individual pursuing its course on either side of the equator—one towards the north, the other towards the south pole.

Hurricane may occur on any meridian between Madagascar and Australia.

107. The possibility of the production of hurricanes in the Indian Ocean, on any meridian between Madagascar and Australia, renders it extremely important to determine whether the cyclones recurve on the *same parallel*, or whether they follow any particular law in this respect; and this is the more essential, as the great oceanic highway from India and China passes immediately through the tracks of most that have hitherto been observed. In the Northern Atlantic we have seen (sections 76 to 97) that, although several hurricanes recurved on the parallel of 30°, yet this was not constantly the case; some recurved in higher and some in lower latitudes; and in the same way, although the parallel of 30° may be regarded as the latitude of recurvature in the Indian Ocean, yet some cyclones have been found to recurve nearer to the equator than this latitude. There appears, however, to be a most important difference between the phenomena of recurvature in the northern and southern hemispheres. In the northern hemisphere the latitudes of recurvature do not appear to be regulated by any general law, while in the southern hemisphere there is some reason to believe that cyclones produced in the more easterly regions of the Indian Ocean recurve on lower latitudes than those originating near the middle or western portions of the ocean; and not only does this regularity apparently obtain, but the points of recurvature appear to be such as to indicate a general line of a somewhat curved form, extending from east to west, on which the cyclones recurve. Our present knowledge will only allow us just faintly to indicate the existence

Probability of a line of recurvature existing in the Indian Ocean, and

of such a line, but it must be at once apparent how exceedingly valuable it will be to ascertain if it really exist, as, from the points already determined, the line of recurvature would coincide for about 30 degrees with the track of vessels from India and China, viz., from 80° to 50° of east longitude. Table XIX, p. 82, exhibits the latitudes and longitudes of all the hurricanes yet known to have recurved in the Indian Ocean. With four exceptions, the recurvatures have occurred in *lower* latitudes, or nearer the equator on the more *eastern* meridians, and the few instances following the apparent "law" certainly agree with the idea of the existence of such a line of recurvature. In the diagram, fig. 30, p. 82, the points of recurvature are inserted, the letters agreeing with those in column 1 of the table, and the line of recurvature is projected. It will readily be seen, from this diagram, that the greatest number of cyclones recurve in the space between 50° and 70° east longitude, and 20° and 30° south latitude. This area may therefore be regarded as the most dangerous part of the Indian Ocean, from the great liability of a commander meeting a recurving cyclone. The space between 60° and 65° of east longitude, and 20° and 30° of south latitude, is the most stormy part of this area, a considerable number of hurricane paths having met and crossed each other within it. The dotted line W to *g*, shews the apparent line of recurvature, and may, we apprehend, in our present knowledge of the "law of storms" be found of considerable use in these seas. As a general principle, we may regard all the shaded space as particularly liable to hurricanes; the usual locality of their recurvature has already been pointed out, but the commander may gather from the cyclones N, *jj*, and W, that when sailing anywhere near the line W to *g*, between November and April, he is constantly liable to sail into a cyclone, or to be overtaken by one as it recurves; and his difficulty in either case must be proportionally increased, when it is considered that, in addition to his sailing into or

coinciding with the usual track of vessels from India and China to Europe.

being overtaken by a hurricane, it is at the same time moving but slowly, and about to alter its course. Many vessels have been lost in consequence of falling in with cyclones just at the point of their recurvature; and we cannot too strongly endeavour to impress on the minds of seamen the great importance of contributing all in their power towards the determination of a question that will in no small degree acquaint them with the precise phenomena they may be prepared to experience in any portion of the Indian Ocean.*

Importance of increasing our knowledge of this line of recurvature.

108. The line of recurvature has also another use. Hurricanes are common in its neighbourhood, and they become fewer as the commander recedes from it, either to the N.W. or S.E.; there is, however, this important difference—most of the cyclones in its immediate neighbourhood, and to the north-west of it, move towards the W.S.W. and S.W. before recurving, and those on the S.E. move from it towards the S.E. after recurving. It is highly probable that the greatest number of cyclones occur in the neighbourhood of the line of recurvature, but we must not conclude from this that they are rare, especially toward the S.E. The usual tracks of vessels pass directly through the hurricane region, which of course will multiply *their* tracks in these latitudes.

Directions in which Cyclones move N.W. or S.E. of the line of recurvature.

109. The report of the meeting of the British Association for the Advancement of Science at Bradford, in 1873, contains, pp. 466–478, a paper, by Meldrum, of the Mauritius, "On the Periodicity of Cyclones and Rainfall in connection with the Sun-spot Periodicity." In this paper Meldrum gives a chronological list of 227 cyclones experienced in the Indian Ocean between the equator and 36° of S. latitude, and from 18° to 120° of E. longitude. It commences January 1, 1847, and ends May 31, 1873, and gives the maximum

* The diagram, fig. 30, embraces the present extent of our knowledge of recurvature in the Indian Ocean. Any additions in the shape of extracts from logs of vessels meeting with hurricanes either pursuing a W.S.W., S.W., or S.E. course, or when recurving, will be peculiarly acceptable. They may be forwarded to the publishers.

force of wind in each cyclone—from 9, a strong gale; 10, a whole gale; 11, a storm; to 12, a hurricane. Table XX. contains an analysis of the number of storms met with in this extensive area, embracing 102° of longitude. It is divided into seven zones, with the limiting latitudes and longitudes of each; the number of cyclones in each; also the number of storms which attained the strength of wind specified.

TABLE XX.

Hurricanes in the Indian Ocean, January 1, 1847, *to May* 31, 1873.

Zone.	No.	Limits.		Extent.		Strength of Wind.				No.
		Lat.	Long.	Lat.	Lon.	9	10	11	12	
I.	29	0° to 25°	50° to 95°	25°	45°	2	9	9	9	29
II.	57	8 „ 38	40 „ 110	30	70	6	11	15	25	57
III.	46	12 „ 35	49 „ 103	23	54	2	10	7	27	46
IV.	45	15 „ 33	31 „ 120	18	89	5	10	9	21	45
V.	22	20 „ 32	45 „ 113	12	68	4	10	3	4	21*
VI.	15	25 „ 33	41 „ 82	8	41	4	3	4	3	14*
VII.	13	30 „ 36	18 „ 78	6	60	3	8	2		13
Totals.	227					26	61	49	89	225

Zones II., III.—There have been recorded in Zone II., of 30 degrees of latitude and 70 of longitude—viz., from 8° to 38° S., and 40° to 110° E.—fifty-seven storms, ranging in wind-force from 9 to 12. Forty-six storms have been met with in Zone III., of 23 degrees of latitude and 54 of longitude—viz., from 12° to 35° S., and 49° to 103° E. This zone is of course included in Zone II., consequently in this zone storms are more frequently encountered than in any other part of the Indian Ocean, 103 having been recorded within its limits.

110. In addition to the central portion of the Indian Ocean being characterised by storm-paths possessing certain features referable both to geographical distribution and the influence of season, there are outlying groups, if we may

* One ship not reported in each zone.

use the expression, fringing the main body, and which, in their turn, exhibit the influence of season, certainly in the production of cyclones, if not in their direction. Commencing at the Cape of Good Hope, and proceeding to the eastward, we find six such groups—viz., the Cape cyclones; those of the southern Indian Ocean; the cyclones of Western Australia; those of the sea between Java and Australia; the cyclones of the Mozambique Channel; and a small outlying group south of Madagascar. We shall consider them in the order here enumerated.

Groups of storm-paths fringing the main body in the Indian Ocean.

111. *The Cape of Good Hope.* On the authority of M. Bonsquet, Mr. Piddington has inserted the tracks of four cyclones encountered south of the Cape, with a general direction of W.N.W.—E.S.E.; they all occurred in the months of March and April. At the opposite season of the year, viz., September, Mr. Piddington adds a fifth moving north of east, or about E.N.E.

Storm-paths south of the Cape.

While this sheet is passing through the press, we are enabled, by means of logs kindly communicated by H. Rosser, Esq., to add a sixth—viz., that of the severe gale in which the "Grindlay" was abandoned, and the "Asiatic" became a total wreck. The information contained in the logs of these vessels is hardly sufficient to determine the extent of the cyclone; its path, however, is indicated as *coming up from the S.W. towards Capes St. Francis and Recife.* This direction, to a certain extent, agrees with that of Mr. Piddington's hurricane, and crosses the paths of M. Bonsquet's cyclones. The hurricane of the "Grindlay" and "Asiatic" occurred in June 1850. About the time of the setting in of this hurricane, there were indications of a revolving storm at Cape Town passing from north to south.

Cyclones of the Grindlay and Asiatic.

112. *The Southern Indian Ocean.* We have between the meridians of 45° and 95° east, the tracks of two hurricanes with an easterly direction of motion; they occurred

The Southern Indian Ocean.

Vessels may benefit by cyclones near 40° south latitude.

in the months of July and September. Vessels from the Cape to Australia, by keeping northward of the parallel of 40° during the winter months of the southern hemisphere, will find the cyclones of considerable benefit; for by sailing on a course nearly parallel with the centre of the storm, and at such a distance from it on its northern radius as to get a steady breeze from the westward, they will make very good runs, and reach their destination with but little if any delay. In most instances the speed of the gale will outstrip that of the ship, and she will be gradually left in the receding quadrant of the left-hand semicircle.

In addition to the logs of the Grindlay and Asiatic, we are also indebted to Mr. Rosser for that of the "Duke of Richmond," Captain Barclay, which fell in with a severe hurricane in latitude 41½° S., longitude 115½° E., on the 13th of October, 1851. Its path appeared to be towards E. by S.

Upon combining Mr. Piddington's storm-track south of the Cape (E), which occurred in September, 1849, with Captain Barclay's hurricane in October, 1851, we have four storm-paths south of the 40th parallel, apparently conforming to a very regular law of progression. On the western side of the Indian Ocean, the direction appears to be E. by N., in the central portion due E., and in the eastern, off Australia, E. by S. The adoption of great circle sailing in these seas will doubtless make us acquainted with numerous hurricanes, and it will be a question for commanders to decide between the relative claims of the cyclone, or the great circle sailing, to help them on their course. Captain Erskine, of the Havannah, made a passage from Simon's Bay to Port Jackson, by the help of the cyclones in these seas, in thirty-four days, *with moderate weather*. Captain Barclay's passage, from the meridian of the Cape to 40° S. and 135 E., was forty days, he having encountered *a severe hurricane which forced his lee side entirely under water*

for some hours, stove his quarter boat, hen-coops, &c., and occasioned other damage. For an important paragraph on "Cyclone Sailing," just north of the 40th parallel, see PIDDINGTON'S *Sailors' Horn Book*, second edition, page 35.

Storm-paths off Western Australia.

113. *Western Australia.* Our knowledge of storm-paths off this coast is very limited; the few recorded instances, however, indicate a point of recurvature in the same parallel as the most southern points of recurvature in the Indian Ocean, viz., about 29° south. A hurricane that passed over Shark's Bay in February 1844, moved towards S.S.W.; another, in 29° S., moved from west to east in May 1840; and a third, encountered by H.M.S. Beagle in May 1844, moved towards the S.E. These movements agree with those of cyclones encountered on the more westerly meridians.

The sea between Java and Australia.

114. *Sea between Java and the north-west of Australia.* By the conjoint labours of Messrs. Piddington and Thom, we have this portion of the Indian Ocean moderately scattered with storm-paths, and it is to be hoped commanders of vessels navigating these seas will take every means of increasing our information. The following table exhibits the distribution of the cyclones as to season, including the Shark's Bay hurricane:—

HURRICANE SEASON, JAVA SEA.

Dec.	Jan.	Feb.	March.	April.
2	3	5	1	1

So far as season is concerned, these cyclones agree with those of the main body of the Indian Ocean; their tracks vary in direction from S.S.W. in December, to S.W. in April; and they may generally be considered as conforming to the usual tracks in the same parallels to the west. There are one or two anomalies, particularly the hurricane of H. C. S. Macqueen, January 1827, in longitude 100°, which appears to have recurved in a still lower latitude than that of the

City of Poonah (W, fig. 30). We have yet to learn if the neighbourhood of the Cocos Islands divides this group from the main body of cyclones, or whether a general hurricane track exists from Madagascar to Timor.

Mozambique Channel.

115. *The Mozambique Channel.* Two cyclones have been encountered here in the month of January, moving towards the S.W. The island of Madagascar separates this group from the main body, although, as to direction and season, the storms conform to those observed in the same parallels to the eastward.

South of Madagascar.

116. *The outlying group south of Madagascar.* This group, the hurricanes of which were encountered in the months of February and March, although so close to the main body, differs from it very materially as to direction. In a latitude higher than any point of recurvature yet observed, these hurricanes were moving in a direction varying from east to west to N.N.E.—S.S.W. It will be well for commanders to keep a sharp look-out for these erratic cyclones.

117. Upon the whole, the entire area of the Indian Ocean may be divided into two large portions, separated by the parallel of 30°. North of this parallel the cyclones move westwardly, at all events, previous to arriving at their points of recurvature, their season extending from November to May. South of 30° the hurricanes move eastwardly, and, with the exception of the latter branches of the northern cyclones, occur in the opposite season, viz., from the months of March to November.

Cyclones north of 30° south move westwardly.

Those south of the same parallel move eastwardly.

THE CHINA SEAS.

118. The same reasoning relative to the production of revolving storms on or near the borders of zones, characterised at the same time by the active precipitation of aqueous vapour, applies with equal force to the typhoons of the Chinese Seas as to the storms in the localities already specified. Just to the south of the eastern district of the monsoons, we find the

Meteorological relations of the West Indian hurri-

resumption of the zone of variable winds and calms; and the occurrence of the typhoons at *nearly* the same season as that of the West Indian hurricane, clearly points to the causes of the two being identical. It is to be remarked that the southern limit of the typhoon district nearly coincides with the limit of the monsoon, and also, that part of the typhoon limit merges into the monsoon district; and here it is that *difference* of season between the two sets of hurricanes appears to receive its explanation, the typhoon region partaking somewhat of the nature of the hurricane region in the Bay of Bengal. The following table of the distribution as regards season of cyclones in the China Sea will exhibit this:—

canes and the typhoons of the China Seas similar.

HURRICANE SEASON, CHINA SEA.*

June.	July.	August.	Sept.	Oct.	Nov.
2	12	5	16	14	11

* There is some reason to believe that cyclones occur in the China Seas in the month of May, but the information at present obtained is not sufficient to include it in the hurricane season. Rosser classes the China Sea and the west part of the North Pacific as constituting one hurricane region, "because the monsoons are prevalent over both," and he gives a table of seventy-five hurricanes met with in these seas during the months May to December, as follows:—

May	4	September	22
June	2	October	15
July	13	November	12
August	6	December	1

This table agrees with the one given in the text, the occurrence of hurricanes in the first three months of the one, and four months of the other, being as 1 to 2 in comparison with the last three and four months respectively. The following remarks of Rosser are important:—"As regards the China Sea and China coast there appears to be no particular seasonal storm-path; it may be rectilinear, or curved towards the north, south, or west at any time, and without any apparent cause; but the preponderating paths are rectilinear and often along the coast. The effect of the high land of Formosa in diverting the storm northward or southward has long been noticed in those that commence eastward of that island; *none cross it*, as is often the case with the typhoons off the Philippines. Recurvature is only clearly marked in the western Pacific and off the Japan coast, especially in the instances of such storms as originate near the Mariana Islands in October; these recurve off the Bonin or La-chu Islands. Recurvature has been seen in the hurricanes between the Carolines and Marianas. Typhoons have been experienced off the coast of Japan in July, August, September, and October."—*Rosser's Law of Storms, p.* 99.

119. The following tables exhibit the geographical distribution of hurricanes in the China Seas, with their direction of motion, both as regards locality and season; it is to be understood that the cyclones moved *towards* the points specified in the second column. The first column contains the references of each cyclone to Mr Piddington's Map:—

Loo Choo Sea.

Reference	Direction.	Month.
r	N.W.	September.
s	N.W.	September.
a a	W.N.W.	July.

West and South of Formosa.

Reference.	Direction.	Month.
u	E.N.E.	September.
ff	N.N.E.	July.
m	N.W.	September.
l	S W. by W.*	September.

Pacific Ocean.

Reference.	Direction.	Month.
b b	N.W.	July.
d d	W.N.W.	July.
c c	W.N.W.	July.
i	W. by N.	October.
e e	W. by S.	July.

* From Mr Piddington's Map, it is doubtful in what direction this hurricane was moving; it might have been the opposite, or N.E. by E.

China Sea—*North.*

From 19° to 23° north latitude.

Reference.	Direction.	Month.	Remarks.
XXX	N.W.	July	Macao.
XXIII	N.W.	...	
XXIV	W.N.W.	August	Macao.
k	W.N.W.	July	...
VIII	W. by N.	October	Easterly.
XIX	W.	August	Macao.
II	W.	June	...
v	W. by S.	July	
h	W.S.W.	October	
I	W.S.W.	July	Macao.
XV	W.S.W.	September	...
IV	S.W.	...	
XI	S.W.	...	
V	S.W.	...	
XXIX	S.W. by S.	July	Macao.
n	W.S.W., N.W.	September	Recurved
z	N.W., N.N.E., E.	November	...

China Sea—*Central.*

From 16° to 19° north latitude.

Reference.	Direction.	Month.	Remarks.
XXII	N. by E.	October	
XXVI	N.N.W.	September	
j	N.W. by N.	June	
XXI	N.W. by N.	August	
x	N.W.	November	
XXVII	W.N.W.	September	
VII	W. by N.	...	
t	W. by S.	October	
X	W.S.W.	...	
XVIII	W.S.W.	...	
e	W.S.W.	November	
VI	W.S.W.	September	
XX	S.W.	October	
w	S.S.W.	November	
III	N.W., W.N.W.	September	Recurved

CHINA SEA – *South.*

From 9° to 16° north latitude.

Reference.	Direction.	Month.	Remarks.
XVII	N.W.	October	
XXVIII	W.N.W.	November	
XII	W.N.W.	September	
XVI	W.N.W.	October	
IX	W.	November	
g	W. by S.	...	
q	W.S.W.	...	Manila.
o	S.W.	October	...
p	S. by W.	...	...
η	S.	November	...
XXV	W.N.W., W.S.W.	...	Recurved

120. From the above tables, it would appear that an important relation exists between the geographical distribution of cyclones in the China Sea, the seasons in which they occur, and the directions in which they move. In the northern portion, comprehended between the coast of China, the Bashee Isles, and 19° of north latitude, we have tracks varying from N.W. to S.W. by S., or nine points, occurring in the months from June to September, July and September furnishing the greatest number. We find, also, that in June, July, and August, they occur mostly in the neighbourhood of Macao; while in September, as the sun is moving southerly, they are found in lower latitudes. This peculiarity is so striking, that we cannot hesitate to refer the Macao hurricanes to the solar influence, as the sun is leaving the northern tropic during the prevalence of the rainy S.W. monsoon.

Cyclones near Macao in June, July, and August.

121. In this district of the China Sea (*the northern*) we meet with a class of storm-paths very slightly developed in the Northern Atlantic, and rather more so in the Bay of Bengal. We allude to the oblique movement of a hurricane *from the pole to the equator.* We find eight instances of this kind of movement characterising both the July and September cyclones; and, in addition, we have a most re-

Hurricanes moving from the pole to the equator.

markable case of recurvature, the apex occurring towards the *south*, the earlier portion of the track being directed towards W.S.W., and the latter towards N.W. There can be very little question that this extraordinary path resulted from the combined agencies producing the usual storm-tracks of the locality.

Remarkable instance of recurvature.

122. Turning to the central portion, or that bounded by the islands of Hainam on the west, Luzon on the east, and the parallels of 19° and 16° north and south, we have a much greater range of storm-paths, viz., from N. by E. to S.S.W., or nearly 180 degrees—September, October, and November being the usual months in which they occur. We have only two tracks in the earlier months of June, July, and August; consequently, these two portions of the China Sea, although so near each other, have their hurricane seasons very distinctly marked. *The oblique movement of the hurricanes from the pole to the equator* is also recognised here, as in the northern division, and about as equally developed; for, although we have but seven instances, the track of the cyclone *h*, which commenced in the northern portion, was principally through the central. In this district two instances of recurvature occur, one precisely of the opposite character to that in the northern, the other somewhat approximating in its general features to the recurvatures observed in the Northern Atlantic.

Storm paths of the central portion of the China Sea.

Season September, October, and November.

Hurricanes moving from the pole to the equator.

123. The southern district, extending between the coast of Cochin-China on the west, to the Phillipines on the east, and the parallels of 16° and 9° north, furnishes a class of storm-paths rather more confined in their range as compared with the storm-paths of the central division, but more excursive than those in the northern; they occur between N.W. and S. in the months of September, October, and November; but mostly in the latter two, one only having been observed in September; and this district also agrees with the other two in furnishing storms moving

Hurricanes prevalent in the southern part of the China Sea in October and November.

from the pole to the equator; we have five instances, four in the neighbourhood of Manila. We have also a case of recurvature of a somewhat similar character to those noticed in the northern and central divisions.

Recapitulation.

124. From the above remarks on the cyclone tracks of the China Sea, the commander will conclude that, if he be sailing in the northern division, especially in the neighbourhood of Macao, any time between May and October, he is liable to meet with typhoons. In the central portion he is more likely to fall in with them in September, October, and November; earlier, they are comparatively rare; and in the southern division he meets with them principally in the last two months, two only having been observed in September.*

Cyclone divisions of the China Sea.

125. In addition to the above geographical division of the China Sea, there is another, having special reference to the cyclone tracks themselves. Only four instances of recurvature have been observed within its area, of which three lead to the idea not of a parallel of latitude on which

Meridian of recurvature.

the hurricanes recurve, but of a meridian of longitude. The longitudes 116° to 118° east, may be regarded, from the scanty information we possess on this head, as including the meridian of recurvature. The forms of the curves differ very considerably from those of the Atlantic or Indian Oceans, the branches being essentially straight lines. With the exception of the four instances above mentioned, all the tracks are straight lines, and it would appear that the recurvatures result, at least in this locality, from the conversion

* In the Northern Pacific, 19° north, 138° east, a severe cyclone has been encountered at its point of recurvature in the beginning of May; and in November, a small but very severe one in 19° north, 146° east. In the Southern Pacific, Navigators' Islands, cyclones are met with in April moving towards W. by S.; and there is great reason to believe that the space between the Feejee group and New Zealand is distinguished as a stormy district, the cyclones moving *from the equator.* The season in the Feejees extends from November to March; and there appears to be some indications of hurricanes in this locality moving *from the pole to the equator.* Information from vessels sailing in these localities will be very valuable, as connecting the north and south cyclones with the two storm localities of the China and Java Seas.

of one straight direction line into another, in consequence of the original propelling force, whatever it may be, becoming weaker, while that which is capable of carrying the cyclone in its new direction, is either newly developed, or if it existed before, its mode of operation becomes stronger; the gradual diminution of velocity observed in cyclones as they approach the points of recurvature, renders it very possible that this is the case.

126. A careful consideration of Mr Piddington's map of the storm-tracks of the China Sea will lead to the conclusion that this line not only characterises the points of recurvature, but also separates the sea into two areas, the storm-paths in the western portion, but slightly inclined to the meridian, indicating that the cyclones moved to the westward of north, while those in the eastern portion, also slightly inclined to the meridian, shew that the cyclones were moving to the eastward of north. It is true this line is crossed by cyclone tracks towards the N.W., and also towards the S.W. from the eastern portion; but the tracks above mentioned, so far as we yet know, diverge in the manner indicated, an instance of a N.N.E. track not having occurred westward of the line of recurvature.

Diverging Storm-tracks east and west of the line of recurvature.

127. Another important feature of the storm-paths, especially in the southern district of the China Sea, is their general convergence to the coast of Cochin-China. Only one instance is to be found of a contrary character; and, although this hurricane was travelling "in shore," its direction was such as but little more than to graze the N.E. portion of the coast.

128. We cannot quit this subject without glancing at the important geographical conditions of two hurricane districts, possessing nearly the same configurations of land and water, and similarly situated with regard to the zone of constant precipitation. Now, it is well known that a greater precipitation takes place on coasts exposed to prevailing winds,

Similarity of the geographical conditions of the West Indian and Chinese hurricane regions.

and we consequently find the Windward or Caribbee Islands characterised by a much greater precipitation of rain than the open sea some distance to the east. In the N.E. trade on the open sea it seldom if ever rains, but as we approach the Caribbean Archipelago, especially towards the end of the rainy season, we arrive at a locality of a very different meteorological character, in which we find hurricanes prevailing; and it is to be remarked, that nearly in the same parallels in the Chinese seas a nearly similar distribution of land and water prevails; the Philippine Archipelago determining the precipitation of aqueous vapour during the S.W. monsoon much in the same way as the Caribbean Archipelago determines it in the N.E. trade, the position of the sun being the great exciting cause. There is some reason to believe that as the Atlantic hurricanes originate on the border of the zone of constant precipitation, so the typhoons of China either originate on the northern border of the same zone, east of the monsoon district, or at least the circumstances producing them are induced in that locality.

129. Upon a careful review of all the evidence hitherto accumulated relative to the direction of storm-paths in either of the storm regions of the Northern Atlantic, the Indian Ocean, the Arabian Sea, the Bay of Bengal, or the China Sea, it appears to be the safest mode for the commander to determine for himself, in every case in which he may encounter a cyclone, by the direction and veering of the wind, the course which it is describing, rather than to depend on any usually received statements relative to the general direction of the storm-paths in either hemisphere. We are aware that there is a great tendency in this, as in most other subjects of scientific inquiry, to generalise too hastily, and it may be that a name high in the scientific world speaking of any peculiarity, such as the direction in which hurricanes generally move, may stamp an authority on the statement made which may prevent further inquiry, and lead those most

Commanders to determine the storm-paths for themselves.

interested astray. We have been led to these remarks, as, from the very careful analysis we have endeavoured to present of the storm-paths of the seas above enumerated, it appears that *so few* conform to any well recognised types, that we cannot regard them as moving in trajectories possessing anything approaching to a fixity of geographical position or geometrical form; perhaps there may be a greater adherence to the form in two localities than the position. To quote the words of a celebrated author—"The habitual tracks of hurricanes are but imperfectly known, and all which tends to throw light upon this part of the subject is of the last importance to navigation."*

* Sir John Herschel.

CHAPTER V

METEOROLOGICAL PHENOMENA.

Meteorological Signs indicative of and preceding Hurricanes—Meteorological Characteristics of Hurricanes—Enumeration of Meteorological Signs.

130. It is the opinion of men well conversant with the navigation of the Indian and Chinese Seas that every hurricane is ushered in with the most unmistakeable and distinctly defined meteorological phenomena; the atmosphere assumes an appearance so exceedingly different to that which it exhibits, not only under ordinary circumstances, but even when considerably agitated by a stiff gale, that some commanders have considered that the meteorological appearances are far more certain in their indications than the fall of the barometer; and it is quite true that the *depression* of the mercurial column occurs *after* the vessel has become involved in the gyrations of the cyclone, by which the great value of the instrument is exhibited, not so much in the character of a prognosticator as a guide, informing the seaman, when combined with the direction and veering of the wind, in which direction he should steer his vessel; or, if circumstances prevent his retreating from the centre of the hurricane, when to heave to, that the storm may pass him. There is only one phase which the barometer presents *previous* to the ship being involved, and that is an unusual elevation of the mercury, while in most cases in certain directions the meteorological appearances are so significant as to leave no doubt on the mind that in those directions a cyclone is raging. It must not, however, be overlooked that, under some peculiar circumstances hereafter to be mentioned, a very considerable depression of the barometer may occur previous to a hurricane without the exhibition *at the time* of the characteristic meteorological phenomena, which make their appearance afterwards.

Meteorological indications more certain than the fall of the barometer.

The barometer generally of greater use after than before the commencement of a storm.

The barometer elevated previous to a storm.

Extraordinary depressions of the barometer, unaccompanied by meteorological signs.

131. One of the most striking meteorological indications preceding a storm, is an unusual calmness, accompanied by an oppressive sultry state of the atmosphere, the sky having a lurid threatening aspect, varying in colour from a deep angry-looking red, usually regarded as a prognostic of a gale of wind, to a peculiar, heavy, olive-green appearance, which has characterised some of the most destructive cyclones on record. A remarkable haze is also very apparent, generally in the direction in which the great body of the hurricane is raging; and in connection with this is a most unmistakeable feature, viz., a banking of the clouds in the same direction; the gyrations within the cyclone, and their sucking in fresh cylindrical shells of air, producing, with the progressive motion, a sort of spiral movement, which aids very materially in the condensation of aqueous vapour, so that cloud after cloud is formed, and as the ship approaches the vast and agitated area of the storm, the clouds, like some thing of life, draw down upon and inclose her as if with an impenetrable wall; and so solid do these clouds appear, so unlike the airy structures generally witnessed and wafted by a gentle breeze through the atmosphere, and so close to the vessel do they seem, that commanders may almost fancy they can stretch forth their hand and touch the dark, appalling, and threatening wall before them. The ship comes nearer, the wind freshens, the clouds which a short time previous appeared so dense, and dark, and dismal, are torn into shreds, detached portions fly with great rapidity across the now wild and agitated sky; borne on the wings of the wind, or rather *driven* by its impetuosity, they mark out the course of the gyrating and circling current in which the ship is labouring, and announce that it is no ordinary atmospheric stream with which she has to contend.

Calm and sultry state of atmosphere preceding storms.

Colours.

Haze.

Cloud banks.

Their solid appearance and apparent proximity.

Detached portions torn into shreds, and driven with impetuosity.

She has now fairly entered into the vortex; torrents of rain descend on all sides, vivid flashes of lightning, accompanied, it may be, with thunder, illumine with fitful glare

Rain and lightning within the storm.

the awful darkness that reigns around; but here the poetical idea of "Darkness and silence, solemn sisters twins," is not realised. The whistling and howling and roaring of the winds drown every other sound. Men are unable to hear themselves or each other shout; even the reverberating peals of thunder, that usually strike greater terror into the already terrified spectator of the far flashing and life-destroying lightning in ordinary storms, here have no power of arresting the ear; the wind in its fury, silences every other sound, however magnificent and powerful; and the electric explosion, always grand, fearful, and terrific, affects the sight alone. When the ship passes through the centre of the storm, in the absence of the lightning's lurid glare, and in the midst of the awful darkness in which she is plunged, an obscure circle of imperfect light, generally in the zenith, and subtending an angle of 35 or 40 degrees, is very frequently seen.*

Wind, its excessive howling and roaring so as to drown the pealing of the thunder.

The circle of imperfect light in the centre of the storm, or the storm's eye.

Enumeration of Meteorological Signs preceding Hurricanes.

Enumeration of meteorological signs preceding hurricanes.

132. The meteorological signs indicating the approach of a cyclone may be enumerated and classed as under, according as the phenomena may be presented to the external sensations of feeling, sight, or hearing.

Those recognised by feelings, as sultriness and calms.

Meteorological signs recognised by the feelings:—

1. A sultry, oppressive state of the atmosphere.
2. A calm.

Those recognised by sight, as coloured appearances &c.

Meteorological signs recognised by the eye:—

3. A remarkably clear state of the atmosphere, so that the stars may be seen to rise and set with nearly the same distinctness as the sun and moon.

* This circle of imperfect light is generally supposed to arise from the *thinness* of the cyclone disc near its centre. On many occasions the disc has been seen through, the clouds have separated, and the blue colour of the atmosphere has appeared. At night, the stars have been seen shining brilliantly when the cyclone has been at its greatest height.

4. A peculiar white appearance in the zenith, more or less of a circular form.
5. A remarkably red or fiery appearance of the sky.* Red light.
6. A peculiar colouring of the clouds, more especially of an olive green.† Clouds olive-green.
7. A thick, hazy appearance in that quarter of the horizon in which the cyclone is raging. Haze
8. A remarkable and peculiar appearance of the heavenly bodies. When shining through a haze, they are said to shine with a pale, sickly light, and are not unfrequently surrounded by rings of light, or halos. Some observers describe the stars as "looking big with burrs about them." Others speak of their dancing; and, generally, they have been noticed as being remarkably bright and twinkling. Halo. Stars.
9. The sun on some occasions has exhibited a *blue* appearance, and white objects have been seen of a decided light-blue colour. The sun has also been observed of a pale and somewhat similar appearance to that of the full moon. Sun.
10. A dense, heavy bank of cloud in the direction of the hurricane. Banks.
11. A peculiar appalling appearance in this bank, more particularly as if it were a solid wall drawing down upon and closing around the ship.
12. A darting forward of portions of this bank, as if torn into rags and shreds by some violent force, and driven before, *not borne* by, the wind.‡ Scud.

* This is not unfrequently of such intensity as to tinge all surrounding objects with a deep crimson; and when this is observed, there can be no question that the violent portion of the cyclone is not far from the vessel. When this red light is seen at night, the impression on the seaman's mind is that "day has broken before its time."

† This is generally the precursor of a most violent and terrific hurricane.

‡ When this indication is distinctly recognised, a run of about two hours *towards the centre* will involve the vessel in a destructive hurricane.

Motions of small bodies.

13. A peculiar motion exhibited by small bodies, as branches of trees, when agitated by the wind, consisting of a sort of whirling, *not a bending forward, as if bent by a stream of air.*

Lightning.

14. Lightning of a remarkably columnar character, shooting up in stalks from the horizon, with a dull glare, also like flashes from a gun, and sparks from a flint and steel.

Meteorological signs recognised by the ear:—

Signs recognised by sound, as a distant roar or moaning.

15. A distant roar (probably of the hurricane itself), as of wind rushing through a hollow vault.

16. A peculiar *moaning* of the wind, indicative of the close proximity of the violent portion of the hurricane.

Meteorological phenomena accompanying storms.

133. The meteorological phenomena accompanying a revolving storm may also be enumerated thus:—

A rapid motion of the air.

1. A very rapid motion of the air, constituting the hurricane, and increasing in velocity as the centre is approached.

A variation in the force of the wind.

2. A fitful variation of intensity in the force of the wind, which sometimes blows with fearful violence, carrying away everything that opposes its progress, then sinking to a gentle breeze, or even lulling to a calm, but almost immediately afterwards springing up with greater violence than before. The hurricane winds are nearly, if not entirely, without exception puffy, violent, and blowing in gusts.

An immense condensation of aqueous vapour.

3. An immense condensation of aqueous vapour, forming large banks of cloud, which precipitate torrents of rain. The condensation appears to be so exceedingly rapid, that large quantities of electricity are generally developed, giving rise to incessant flashes of lightning.

Development of electricity.

Gloomy and dark

4. A general darkness and gloominess within the area of

the cyclone, relieved only by the fitful glare of the lightning, or the appearance of the imperfect circle of light near the centre or axis of the storm. appearance within the cyclone.

5. A separation of the clouds in or near the centre of the hurricane, so as to produce in the immediate neighbourhood of the axis a clear sky, through which the sun and stars are often seen with great brilliancy. The storm's eye.

6. A calm in the centre of the cyclone. Calm in the centre.

134. Indications of approaching or existing hurricanes manifested by the ocean, of especial utility to vessels at anchor in roadsteads, &c. Oceanic signs indicative of hurricanes.

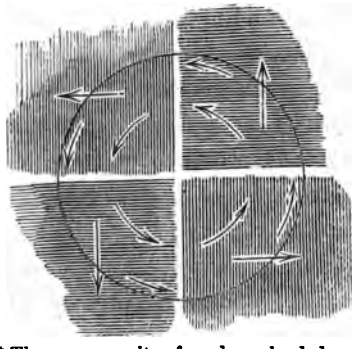
1. A swell produced by the storm-wave rolling in upon the shore, at first of a gentle character. The direction of this swell will pretty surely indicate the bearing of the storm, and its changes will point out, in some localities, the course the hurricane may be pursuing.
2. A swell rolling in, *without changing its direction*, may be regarded as indicative of a hurricane *approaching* the shore. The same phenomenon met with at sea (the ship's course being taken into account), will indicate the bearing down of the cyclone on the vessel.
3. A dirty green appearance of the ocean; on some occasions its assuming a muddy or brown colour, on others its being remarkably clear; its temperature increasing and its smelling stronger than at other times—are all indications of the proximity of a cyclone.

CHAPTER VI.

STORM-WAVES AND CROSS SEAS.*

135. THE immense agitation within the circumference of a cyclone is not confined to the air, but extends also to the surface of the ocean, or even much lower, raising, in many instances, a tremendous sea, which often precedes the hurricane, heralding its approach, while, on numerous occasions, the ship experiences the *ground swell*, as it is termed, without falling in with the cyclone. The production and propagation of the terrific sea accompanying a hurricane being due to the action of the hurricane winds, which, as we have seen, characterise different margins and radii of the storm, it is clear that the storm-waves thus induced will obey the impulses of the winds contributing to their existence, and we shall have as many storm-waves † as we have hurricane-winds —thus, a westerly wind will produce a westerly swell, a northerly wind a northerly swell, and so

Fig. 31.



Hurricane winds produce corresponding storm-waves.

* These are results of, and can be deduced from, the rotatory and progressive motions of storms, and would legitimately find a place in Chapter II. ; but so important do we consider this branch of the subject, and so little is it at present either understood or elucidated, especially for practical purposes, that we prefer treating it in an independent chapter. In connection with the suggestion for inserting the characteristic features in the log, we may here take occasion to state, that we shall be happy to receive, through the publishers, any extracts that may appear of sufficient interest to the commanders, and which shall undergo careful examination, discussion, and comparison with extracts from other logs.

† It may be necessary to remark here, that Mr. Piddington designates these *storm-waves*, *storm-currents*. He has also applied the term *cyclonal-wave* to them.

forth, as exhibited in fig. 31, in which the curved arrows indicate hurricane winds, and the straight arrows the ground-swells or storm-waves produced by them.

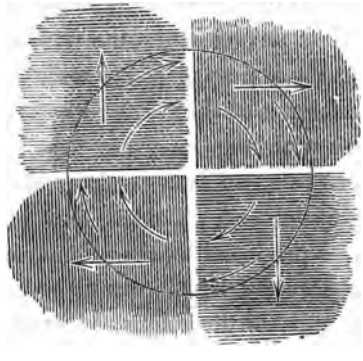
136. The same divisions which have been found so essentially useful in distinguishing and classifying the *anemonal** and barometric phenomena of storms, are not the less important in characterising the undulations that arise from the agitation of the surface of the ocean by the hurricane winds. In the northern hemisphere, the right-hand or starboard semicircle of a cyclone propagates a storm-wave *in advance of*—the left-hand or port semicircle a storm-wave that *rolls back from*—the hurricane. The advancing semicircle, or that which is characterised by a falling barometer, propagates a storm-wave progressing from *right to left*, and the succeeding semicircle, or that in which the barometer rises, propagates a storm-wave from *left to right*. The shaded portions of fig. 31 are intended to indicate the directions of these waves or undulations, and it is extremely easy to deduce that intermediate waves progressing in intermediate directions must exist between them.

Storm-waves of the northern hemisphere.

137. The same reversal of the phenomena of storms in the two hemispheres which we have had occasion so prominently to place before the reader, influences the storm-waves much in the same degree, and produces the same results as we had occasion to notice under the head of dangerous quadrants (see sections 44 and 45). It will

Storm-waves of the southern hemisphere.

Fig. 32.



* Anemonal, a word signifying belonging to, or resulting from the wind; thus, the anemonal phenomena of storms include all the phenomena of the wind, its variations in direction (hauling), force, &c.

Similarity of change in the dangerous quadrants, and storm-waves in the two opposite hemispheres.

be remembered that the advancing quadrant of the *right-hand* semicircle is characterised as the most dangerous one in the *northern* hemisphere; while, in the *southern* hemisphere, it is the advancing quadrant of the *left-hand* semicircle. In like manner, it is the *left-hand* semicircle that propagates a swell in *advance* of the hurricane in the southern hemisphere, while the storm-wave from the *right-hand* semicircle *rolls back from* the cyclone. The advancing semicircle (characterised in both hemispheres by a falling barometer) propagates a storm-wave progressing from *left* to *right*, being the opposite of the direction in the northern hemisphere, while the succeeding semicircle propagates a storm-wave from *right* to *left*. (See fig. 32.)

138. The oceanic phenomena, the production of storm-waves, are so exceedingly simple in their character, as to leave no doubt whatever on the mind as to the real nature of the *ground swells* so often experienced, either accompanied or not by hurricanes; nevertheless the results on different sides of the cyclone are so very dissimilar as to render it important to classify, to a certain extent, the seas that prevail either within the storm area or around its periphery. Within the area of the storm, a tremendous cross sea at all times prevails, which is owing to the *meeting* of the undulations produced by the rotating hurricane winds forming the cyclone. This cross sea is propagated to some little distance beyond the circumference of the storm; its effects, however, do not entirely cease within an area that may be estimated as extending to about two and two-thirds semidiameters from the centre of the cyclone on all sides; that is, the interference of the 32 waves produced by the hurricane winds agitating the surface of the water extends over this area: beyond it the undulations roll on in the directions of the original impulses, the segments of interference gradually lessening, until they are not only separated, but have become so entirely weakened as to be scarcely perceptible.

Cross sea within the storm area, and beyond its periphery.

Variations in the character of the cross seas depending on the force of the wind.

139. The character of the cross seas will greatly depend on the intensity of the wind producing the waves. In some portions of a hurricane the wind blows with a much greater force than in others. In cases of this nature, the sea will be much heavier, run higher, and, when meeting another of the same character, become so exceedingly confused as to occasion the greatest difficulty in managing a vessel exposed to its fury.

Swell experienced when a ship meets a hurricane,

140. The character of a storm-wave preceding a cyclone differs, as we have already hinted, very materially from one succeeding it. In the instance of a vessel meeting a hurricane on the axis-line, she first experiences the swell of the wave propagated by the perpendicular radial wind of the right-hand semicircle, which, being a single series, is easily manageable. If she meet it, however, directly in her course, it would be an indication of the storm bearing down upon her, although she may be far removed from its influence. The next indication of the approach of the cyclone is in the same line of swell, which gradually but slightly presents a troubled appearance, as if *crossed* by a series of waves moving in very nearly the same direction, the angle at which they cross being but small. This effect, which in numerous instances is so trifling as to be but seldom noticed, is, after a long period, and as the storm and ship are nearing each other, succeeded by a gradual increase of the cross sea, or the vessel rather rapidly plunges into one of a more violent character, the meteorological signs heralding the cyclone beginning to make their appearance at the same time. The nature of the sea experienced, the aspect of the sky, the unsettled state of the wind, now and then a puff more or less violent of the true hurricane wind being observed at intervals as the breeze, which has steadily brought the ship on her course, exhibits symptoms of failing,—announce to the watchful seaman his approximation to the neighbourhood of a revolving storm, into which, if he continue his course, he is likely to sail. Should he

and gets into a cross sea.

Increasing cross sea, accompanied with meteorological signs.

approach nearer, all the indications become more significant, not the least among them being the heavy cross sea running strong and high.

141. Although the nature of the interference of waves clearly indicates the existence of a cross sea *in advance* of a hurricane, it is nothing to compare to the turbulent and mighty hubbub that *follows in its wake*. The cyclone, as it steadily progresses, sends the storm-waves in advance to herald its approach, or give notice of its proximity; and the only interference they experience is from those in their immediate neighbourhood, from ground swells generated by the *advancing* semicircle. The storm-waves of the *succeeding* semicircle, in addition to the cross seas produced by their mutual intersections, are interfered with by the swells occasioned by the marginal wind of the advancing front passing towards the left hand, and the marginal wind of the tail of the hurricane passing towards the right hand; thus the storm's wake is fringed with storm-waves moving right and left, producing a high pyramidal sea, already in a most turbulent state, as having been so lately the theatre of the conflict of the hurricane winds; and this unsettled turbulent cross sea marks the track of the hurricane for many miles; still the regular storm-waves, *rolling back* from the advancing cyclone, ultimately maintain their position, the swell produced by the marginal and radial wind separating the port semicircle into two equal quadrants, being the last to strike any shore or vessel that may happen to lie in the storm's track.

Turbulent cross sea that succeeds a cyclone.

Storm-waves that fringe the right and left hand portions of the storm's wake.

*** The above sections have reference to a cyclone in the northern hemisphere. In the case of a southern cyclone, the ship will meet the swell of the perpendicular wind of the *left-hand* semicircle. The swell of the marginal wind of the advancing front will fringe the *right-hand* side of the storm's wake, and the swell of the marginal wind of the tail of the hurricane will fringe its *left-hand* side. The

Southern cyclone winds producing characteristic storm-waves.

last wave from the receding cyclone that strikes upon any object it has passed, is one that has been generated by the marginal and radial wind separating the *starboard* semicircle into two equal quadrants.

142. In sections 16 and 106, we have called attention to the great probability of contemporaneous storms existing on each side of the equator, and noticed their occurrence. These, of course, will produce swells, rolling respectively towards the north and south, and meeting in the neighbourhood of the equator, where cross seas may occasionally be met with which are of a different character to those prevailing within the range of a single cyclone, inasmuch as they are the result of the two storm-waves moving in opposite or nearly opposite directions, the wind at the time not amounting to more than a stiff breeze from the *west*. Under such circumstances, a cross sea experienced *on or near the equator*, between 60° and 90° east longitude, may be regarded as an indication of the contemporaneous existence of two cyclones on either side.

Equatorial cross seas arising from simultaneous north and south storms, and indicative of their existence.

143. In addition to the storm-waves alluded to in the preceding sections, considerable stress has been laid on a wave styled by Mr Piddington the "wave of progression," and otherwise, according to the same authority, the true storm-wave, as distinguished from the storm-currents. The form of this wave Mr Piddington conceives to be that of a *raised disc*, somewhat similar to the lid of a saucepan; in fact, whatever atmospheric depression may exist within the area of a cyclone, as represented in fig. 27, page 51, such depression occasions an elevation of the waters on the surface of the ocean, as in fig. 33. The rise in the centre is mostly about two feet, so that in a hurricane of 500 miles in diameter, there exists on the ocean surface a rise of one foot in about

Fig. 33.

125 miles; in extreme cases it may be one foot in 100 miles from the circumference inwards towards the centre. Every seaman will at once perceive that a wave of this character bears a very different proportion to the waves generally experienced of from thirty to forty feet high, and 600 feet or more from crest to crest, and compared with them as to height, may be considered small. Still, there can be no question, that although so different in their usual proportions to the ordinary cyclone waves, the waves of progression exert a very considerable influence on the ship's course, especially when she is in a hurricane, by causing her to *drift* in a most unaccountable manner. Colonel Reid says:—"I think it probable that the heaviest swell proceeding from a storm may be that which is propelled forward in the track which the storm itself is following, as the undulations in this case would be constantly receiving renewed impulses from the storm in its progression." The heaviest swell which the Colonel speaks of arises from the combined influence of these two waves—the wave of progression and the cyclonal wave, according to Mr Piddington. Now, the wave of progression must partake of the nature of a wave of the first order—the "wave of translation," as it has been called, the laws of its motion being very different from those of the ordinary cyclone waves. The seaman will best understand the nature of this wave by likening it to "a tide;" it is, in fact, *an elevation* on the surface of the ocean, *which rolls onwards in the direction in which the cyclone itself is moving;* but as its velocity depends (if it be a wave of the first order) on the depth of the ocean, it is not only found in advance of the storm, but greatly outstrips the velocity or speed of the ordinary storm-waves. Now, the most important point in connection with this wave for the consideration of the seaman, is *the manner in which it drifts his vessel.* It has been proved that any floating body

Wave of progression.

on the surface of a wave of translation *is carried forward in the same direction in which the wave is moving, and left after the wave has passed away in an entirely new position;* and as this wave may be propagated to great distances from its originating storm, it is clear that even when no indications of a cyclone are present, a ship, by its influence, may be drifted from her course, and if this may be the case when the cyclone is far distant, her *drift* must be very considerable when she is involved. It does not form a part of the plan of this work to adduce instances, but every commander can call to mind, that when correcting his course and distance by observation, he has found indications of *currents* not generally known, or a considerable change in or even reversal of those well ascertained.

Ships drifting by its influence.

144. The subject of storm-waves is peculiarly important, not only by putting the commander on his guard when he finds an *unaccountable* difference between his observations and reckoning, but also by contributing, in no small degree, to mark out either the direction in which a cyclone may be advancing, or to indicate its proximity even when every other sign may be absent. It would be extremely easy to show that the tracks of the ship and hurricane may be so related, that the vessel may experience a very turbulent cross sea, closely approach the storm, and fall into its wake. Again, in recurving, the ship may be so situated as only to experience the swell and its change, without the hurricane approaching her. A glance at figures 28 and 29, page 58, will shew how this may be effected.

Importance of extending the study of storm-waves.

145. It has been suggested that a great point, especially in this department of the inquiry into the "Law of Storms," would receive very considerable elucidation, if commanders of vessels were to insert in their logs a column to receive the direction and state of the swells experienced, the appearance of the sky, particularly towards that part of the horizon from whence they came, the height of the waves,

Column in log to receive direction, &c., of storm-waves.

and whether they presented, in the slightest degree, the appearance or character of a *cross sea*, and if so, in what direction the additional sea advanced, so as to produce the interference. We cannot too earnestly urge this suggestion, when it is considered that not only is much damage done by heavy seas striking ships, especially within the storm area, but also that the *ground* swells and cross seas exist in accordance with laws as beautiful and regular as those characterising the rotation of the wind, progressive motion, or any other class of phenomena appertaining to hurricanes. Every elucidation of cross seas must, consequently, be of considerable value.

CHAPTER VII.

STORM PHENOMENA EXPERIENCED BY VESSELS IN VARIOUS LOCALITIES.

The Northern Atlantic—The Arabian Sea—The Bay of Bengal—The China Sea—The Indian Ocean.

THE NORTHERN ATLANTIC.

146. In treating of the phenomena presented by revolving storms in the Northern Atlantic Ocean, regard must be had to two very important and essential particulars—viz., the variation of the storm-paths according to season (see sections 76 to 97), and the usual tracks of the ships either to the West Indies or the United States of America.

147. We have already solicited attention to the crowding of the commencements of the storm-paths in the space between the 50th and 60th meridians west, and the 10th and 20th parallels north (see section 92). Through this space, vessels bound to the West Indies, the Caribbean Sea, and the Mexican ports, generally sail, and at any time between the middle of June and the middle of October are liable to sail into a hurricane, or to have one bear down directly upon them. In the first instance, a ship will meet the hurricane winds from the *southern* quarter of the horizon, from which she is not likely to suffer unless she sail *faster* than the storm progresses. Should there be any indications of her so doing, she can readily avail herself of a slight alteration of her course, or of heaving-to to avoid its disastrous consequences. In either case the hurricane will soon leave her.

Liability of hurricanes bearing down on vessels sailing to the West Indies between June and October.

148. In the second instance above suggested, the phenomena and their results are very different;—the hurricane winds the vessel experiences are from the N.E. quarter; the cyclone itself is generally moving faster than the ship can sail; the fall of the barometer indicates the approach of the

Critical position of a ship overtaken by a cyclone.

centre; ahead of the storm are the West Indian Islands; and it requires no ordinary address and skill so to manœuvre the vessel as to avoid the disastrous consequences that have generally resulted when commanders have thus found themselves hemmed in between the islands and the centre of the storm. Generally speaking, if the ship be east of 60°, and in the most dangerous quadrant, *i.e.*, the advancing quadrant of the right-hand semicircle, a bearing away to the N. or N.W., according as the hurricane winds may allow, will usually relieve her; but should she be in the left-hand semicircle, then her standing to the north to avoid the islands must be determined by the circumstances in which the commander may find himself placed, and the extent to which he may be involved, and especially by the consideration that a course to the north will not bring him athwart the centre. It is probable that if he *could* execute the manœuvre upon the earliest symptoms of the hurricane, which are unmistakeable in these regions, he *might* boldly cross the storm's track, and escape its fury; but there are many difficulties in the way of his so doing, his falling in with *northerly* winds not being by any means the least. It has been said, "the further out at sea the better;" and we may add that, in keeping out at sea, the further to the N.E. the better, as there is a certainty of clearing the land, and a greater chance of getting into fine weather, if on the right of the axis-line. During the remaining portion of this navigation—viz., within the Caribbean Sea and the Gulf of Mexico—a most intimate acquaintance with the "Law of Storms" is requisite, as, from the confined area and the varying direction of the storm-paths, it is not only difficult to indicate any precise rules that it may be desirable to adopt, but also to describe the particular phenomena likely to be experienced.

Bearing away to the N. if in the right-hand semicircle.

Crossing the storm's track and bearing away to the N., if in the left-hand semicircle,

should it be practicable.

149. Vessels sailing to the northward of the West Indian Islands, having their courses directed to the Bahamas

Vessels bound to Florida and

Florida, and the Southern States of America, will mostly meet the West Indian hurricanes near the points of recurvature, and will, in the great majority of instances, either sail into, or be overtaken by, the winds of the right-hand or starboard semicircle, or those, more or less, from the *southern* quarter of the horizon. In these localities a standing to the *eastward* will usually relieve the vessel, while a bearing to the N.E. is likely to be attended with a detention within the limits of the hurricane, which has here a great tendency to move towards the N.E. In the left-hand or port semicircle, which is generally between the centre and the land, the commander is called upon to adopt such measures as may appear to him best adapted to avoid the centre; but whatever course he may pursue, regard must be had to the important fact, that the advancing quadrant of the left-hand semicircle creates a "lee-shore," which, as the hurricane progresses, is replaced by a series of "off-shore" winds. If, therefore, a vessel be caught in the advancing quadrant of the left-hand semicircle in this neighbourhood, or indeed on any part of the coast of the United States, she cannot be put on the starboard tack, so that she may *sail away* from the centre, as indicated in section 57. The hurricane winds, trending of the shore, and drifting of the ship, will prevent this; her only course, *if she be near the shore*, is to gain an offing on the port tack; this, as shewn in section 57, will lead her towards the storm's centre, and it will be a point of great consequence to ascertain when to round-to and wait for the more violent portion of the hurricane. In the circumstances under consideration, if the ship be hove-to on the port tack, she will come up to the wind, which will veer aft, and, provided she be sufficiently removed from the land on the one hand, and from the storm's centre on the other, as the storm passes off, her head will be so directed that she can readily resume her course.

the Southern States sailing into the right-hand semicircle,

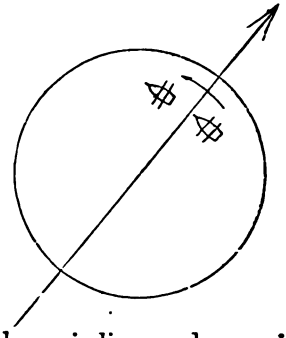
or overtaken by the left.

Lee-shore.

South-easterly winds near the points of recurvature lead to the centre, and should not be regarded as fair winds, being classed amongst the most dangerous.

It is to be borne in mind, that if the vessel experience a S.E. hurricane wind in the neighbourhood of the points of recurvature, and it appear to be favourable to her course, the commander should by no means trust to it, as it will invariably conduct him to the storm's centre, or to the axis-line immediately in advance of it; in fact, throughout the latter branches of the storm-paths in the Northern Atlantic, a S.E. wind is characterised as a most dangerous one—(see "Classification of Hurricane Winds," section 50, also section 32). Colonel Reid recommends vessels falling in with a S.E. hurricane wind, in the higher branches of the storm-paths, to "stand on," as by "heaving-to" they would be waiting for the hardest part of the gale to pass over them. This direction of course alludes to vessels on the axis-lines of hurricanes moving towards the north-east, and in such cases, by following it, a vessel will soon find herself in the left-hand semicircle (see fig. 34), with a fair wind, as in instances adduced by the Colonel. We have however already seen that although the storm-paths may in general be north-easterly in latitudes north of 30° and 35°, yet we have instances of storms moving on a still more northerly course, and in such cases, by "standing on," the ship may be caught right in front of the axis-line, and experience great difficulty in extricating herself. We have already alluded to cases of this kind in sections 20 and 32.

Fig. 34.



Vessels on the southern course to America cross the tracks of the hurricanes,

150. Vessels sailing on the southern course to North America will generally *cross* the tracks of the hurricanes, and, if they sail into the cyclones, will meet the starboard winds, or those from the S. or S.W. In the case of a hurricane meeting the ship, she will experience the port winds generally between E. and N.E., and her situation becomes

more or less critical according to her proximity to the land or centre of the storm.

151. Vessels sailing on the northern course to North America will directly *meet* the cyclones as they are advancing towards the N.E., and if they continue their course, will rapidly plunge into the vortices; but, by standing to the E.S.E. or S.E., according as the starboard hurricane winds may allow, they will, in the great majority of cases, avoid the centres, especially if they meet the starboard semicircles of the hurricanes. Should they be near the axis-line, and have sufficient sea-room, they may pass into the left-hand semicircles, and either take up a good position or meet with a fair wind.

while those on the northern directly meet the advancing cyclones—these vessels should stand to the S.E. if practicable.

152. Vessels bound to Europe from any port in the United States will either experience the winds of the left-hand semicircles, as the hurricanes sweep along the coast, or sail into those semicircles at some distance from the land. In both cases they will experience *northerly* winds, veering more and more to the *westward*, or against the sun. The winter hurricanes of the higher latitudes have not yet been sufficiently investigated to enable us to delineate their paths with accuracy, but it is supposed they extend entirely across the Atlantic, from the shores of America to Europe, and follow each other in rapid succession, so that vessels—by keeping on and sailing round the margins of the port semicircles, or, more correctly speaking, on a semicircle sufficiently removed from the margin towards the centre to give a spanking breeze, and at the same time to avoid any disastrous consequences from the cross seas—may make quick passages from America to Europe during the winter months; and here the barometer is of vast importance, for by its aid the commander may so manœuvre as to keep just within the effective hurricane wind for his purpose.

In immediate connection with the phenomena presented to vessels bound from the United States to Europe, we may

take occasion to remark, that the advancing and receding semicircles of revolving storms furnish commanders with the means of making *quick passages* to or from America. The particular directions may be embodied in the following general rules:—

Quick passages.

General Rules.

Starboard Semicircle.

THAT VESSELS BOUND WESTWARDLY, WHEN MEETING WITH THE STARBOARD SIDE OF A REVOLVING STORM, SHOULD NOT "CARRY ON," BY WHICH THEY MAY SAIL OR STEAM INTO THE HEART OF THE HURRICANE, BUT SHOULD SAIL ROUND THE ADVANCING FRONT, SO AS TO MAKE GOOD NORTHING AND WESTING BY THE HELP OF THE S. AND S.E. WINDS, AND TAKE UP A GOOD POSITION IN THE LEFT-HAND SEMICIRCLE WITH A FAIR WIND.

Port Semicircle.

THAT VESSELS BOUND EASTWARDLY, WHEN MEETING WITH THE PORT SEMICIRCLE OF A REVOLVING STORM, SHOULD TAKE IMMEDIATE ADVANTAGE OF THE NORTHERLY WIND AND SAIL ROUND THE HEEL OF THE HURRICANE, KEEPING WITHIN THE INFLUENCE OF THE WESTERLY WIND AS LONG AS THE DIRECTION OF THE STORM WILL CONTRIBUTE TOWARDS FACILITATING THE VOYAGE.

It is requisite, in sailing round the advancing front, as directed in the rule for the starboard semicircle, to exercise great caution, and to edge away to the north-east, that the vessel be not caught on the axis-line, *too near* the centre to extricate her from danger. Not only is a close attention to the barometer essential, by keeping it well up, &c., but the manœuvre should be executed upon the *earliest* symptoms of the southerly wind setting in, and the commander should not forget that he is here in the most dangerous quadrant, and by successfully crossing the storm's track, he gets a fair wind for his voyage; whereas, if he "carry on" through the heart of the gale, what he gains one way

he loses the other, by meeting with contrary winds, damage, &c.* If, however, the gale should be very extensive, and there should be indications of the commander being *unable* to cross the axis-line successfully—a point that requires the deepest consideration—the best and most prudent course would be to heave-to, and allow the centre to pass the meridian of the ship; this will be known by the wind veering to *west;* and if he find, while thus waiting, his barometer to fall considerably, and the wind to increase inconveniently in force, a standing to the east or southward of east, will improve his condition until he gets clear of the cyclone.

Course to be adopted if the hurricane be too extensive to carry out the rule.

153. From a careful review of the phenomena above specified, it will be seen that, while the advancing quadrant of the right-hand semicircle is in all the storms of the northern hemisphere the most dangerous, inasmuch as, by putting the ship in this quadrant before the wind, she invariably approaches the axis-line, yet throughout the general course of the Northern Atlantic storms, the left-hand semicircle is fully as dangerous, if not more so, because in almost all instances a ship in the left-hand semicircle is between the land and the storm's centre, a position in which

The left-hand semicircle quite as dangerous as the advancing quadrant of the right in

* The manœuvres here recommended are applicable to vessels navigating the Northern Pacific, especially ships bound to China. In these seas commanders may fall in with hurricane winds on the northern verge when the cyclones may be moving towards the N.N.W., and by keeping on their course may rapidly near the axis-line. In such cases, a sailing round the advancing front, edging away to the northward, and keeping the barometer well up, will bring them into the left-hand semicircle with fair winds; but it is necessary to adopt these measures early, when the sky, sea, and wind all testify of the proximity of a cyclone. If the monsoon haul to the southward of east, or the vessel experience puffy and occasionally violent winds from the S.E., although but a temporary gale may be anticipated, and the commander may hesitate about taking in one or two reefs, yet, upon the manœuvres above recommended being adopted, the ship is kept out of harm's way. On the other hand, if, with the wind, sea, and sky all indicating the presence of a cyclone, the commander fail to recognise it, until by stress of weather he is compelled to heave-to, it is ten to one but he loses at least his topmasts, and may think himself well off if he escape without further damage.

the Atlantic storms.

many trying cases may arise, calling for the exertion of all the knowledge, skill, and energy a commander may be able to summon to his aid.

The ascertained storm-paths of the eastern portion of the Northern Atlantic are so few and fragmentary, that no certain indications of the phenomena can be specified.

THE ARABIAN SEA.

154. We have already alluded to the high probability that revolving storms are rare in the Arabian Sea, and also that they occur during both monsoons: it therefore becomes a matter of great importance that the phenomena commanders are likely to experience should, if possible, be particularly described, especially as the storm-tracks appear to run nearly parallel with the Malabar coast during the south-west monsoon, which increases the danger of a vessel getting in between the centre and the land—a point to which we solicited attention under the head of "Atlantic Ocean."

Importance of particularising the phenomena of the Arabian Sea.

155. Vessels bound to Bombay during the hurricane season of the south-west monsoon will in nearly all cases *sail into* the left-hand or port semicircle of a cyclone, should it be raging, and meet with winds from the N.E. and N., or N.W. and W., according as they fall in with the advancing or receding quadrant. Under almost any circumstances a sailing vessel will *meet* a cyclone in the Arabian Seas favourably; and it appears to us that it must be an instance of very bad seamanship indeed if a vessel sailing into a revolving storm in these seas from the west or south-west meet with any damage. It is the right-hand semicircle here that constitutes the most dangerous portion of the storm, both as regards the most dangerous quadrant and the hemming in of the ship between the centre and the land. We have known of vessels meeting the cyclone in the most favourable quadrant, but, deceived

Great probability of a vessel sailing into the left-hand semicircle and meeting the cyclone under the most favourable circumstances.

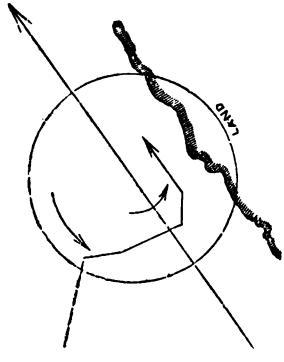
The right-hand semicircle the most dangerous.

by the appearance of a succession of *fair winds*, they have pushed on their course between the land and the centre, until, by the influence of the recurvature, the space has become narrowed, and the vessels lost or dismasted. In sections 34 and 47, we have pointed out the very little danger to be apprehended from a vessel falling in with the westerly winds, as they generally characterise the receding portion of a cyclone. In such cases as above alluded to in the Arabian Sea, a simple heaving-to on the starboard tack* upon the appearance of the significant meteorological signs, will generally allow the cyclone to make sufficient westing and northing, so that its wake may be crossed advantageously; but here much caution is to be exercised, as, should the ship cross the track within the storm area under a favourable wind, and fall in with a southerly wind, which may induce the commander to bowl along at a rate exceeding the progress of the hurricane, she will lose the advantage gained, by shooting ahead of the storm's centre and getting into the most dangerous quadrant, when the centre will rapidly near her. In fig. 35 we see how this may be brought about, as well as the great importance of "waiting on the cyclone" until it has attained sufficient northing and westing to cross its wake with safety.

Westerly winds the most harmless.

Ships to heave-to or wait on the cyclone until it is sufficiently ahead to cross its wake with safety. Great caution requisite to avoid danger by sailing with winds that will entangle the ship between the hurricane and the land.

Fig. 35.



Mr Piddington recommends a vessel sailing into a cyclone, as indicated above, not to heave-to, at all events, with a

* The vessel being in the port semicircle, if hove-to on the port tack, would find the wind veering aft, and it would not be requisite to "wear" when she "stood on" to cross the hinder part of the storm; but in bringing her to on the port tack, her head would be directed towards the storm's centre, and if she forged ahead, she would approach the centre. But "carrying on" when she fell in with the storm on the port tack, she would plunge herself deeply into its heart.

N.W. wind, but to run off E.S.E., hauling up E., and gradually N.E., as the wind hauls to S.W.; *i. e.*, he recommends a vessel to sail round the heel of the hurricane, cross the axis-line behind the centre, and avail itself of the wind of the receding quadrant of the right-hand semicircle. We have known this manœuvre to have been successfully adopted in the China Sea; but whether the commander lies-to or sails round the heel of the storm, as soon as he finds himself in the S.E. quadrant, he cannot be too cautious how he proceeds, especially during the south-west monsoon, for not only does the tendency to recurve narrow the space between the storm's centre and the land, and thus hem him in, but the winds of the receding quadrant of the starboard semicircle create a lee-shore, from which it is necessary he should preserve a good offing.

The Malabar coast a lee-shore.

The reason why Mr Piddington recommends a vessel not to heave-to is, the probability of the cyclone's path being very westerly, and thus the ship would be waiting for the storm. This, according to the extent of our present knowledge, can only have reference to the north-east monsoon, for the cyclones move N.N.W. in the south-west. In the north-east monsoon, they have been encountered moving W. by N.; and under these circumstances, the course recommended by Mr Piddington is by far the best, and by adopting it, commanders will avoid the more violent winds of the storm, and soon find themselves on the receding verge of the hurricane.

Ships meeting the cyclones on the axis-line to make westing and wait on them until they can cross their wakes.

156. If a cyclone meet a vessel from Bombay with a N.E. or E.N.E. hurricane wind, it is highly probable that the centre is immediately approaching it, and a commander will plunge himself into great difficulty by continuing his course. In this case, a standing in the first instance to the westward with the wind on the starboard quarter, so as to allow the cyclone to gain easting of the ship, will be advantageous, that he may be able to take up such a position for bringing the ship to on the starboard tack, that, as the hurricane

progresses, he may experience the least violent winds of the left-hand semicircle, *at a sufficient distance from the axis-line,* until he finds himself in a position to cross the storm's wake if necessary, and pursue his course. After having made a sufficient westing from the axis-line, a south-east course is the best that can be adopted, because, when in the receding semicircle of the storm, the distance between the ship and centre is gradually increasing, and the hurricane winds are favourable for the manœuvre.

Steamships to adopt a similar course.

157. The usual track of the steamers from Bombay to Port de Galle is such, that the vessels are likely to fall in with the cyclones on the advancing quadrant of the starboard or right-hand semicircle—the most dangerous. In this case, it will be even more important to stand to the westward than in the last, as the time lost in steaming, first to the west, so as to cross the storm's path, and then through the less violent winds of the left-hand semicircle, will be more than compensated by the ship's avoiding the great difficulty of contending with violent winds near the centre, and the terrific cross sea that must characterise the portion of the right-hand semicircle between the centre and the coast.

THE BAY OF BENGAL.

Phenomena in the Bay of Bengal and the Arabian Sea similar to vessels bound to Bombay, Madras, and Calcutta.

158. Vessels bound to Madras, Calcutta, and the principal ports in the Bay of Bengal, will generally sail into the left-hand semicircles of cyclones traversing the Bay; and in this respect the phenomena will greatly resemble those presented to vessels navigating the Arabian Sea, the remarks relative to which will equally apply in the present case. Instances have occurred of hurricanes being common to both seas—*i. e.,* a cyclone has commenced in the Bay of Bengal, crossed the southern parts of Hindostan, and passed on towards the coasts of Arabia, the track being slightly north or west. (See section 101.) In such a case as this, and in the open

Cyclones common to the two seas.

portions of the Sea and Bay, a commander will manœuvre according as he falls in with the hurricane and he has more or less sea room, the great object being to avoid the centre. Vessels, however, that may happen to be nearer the Coromandel coast, steam-ships plying between Ceylon and Calcutta, and vessels lying in the roadsteads, will find many difficulties to arise from the eastern coast of India becoming a *lee-shore* as the advancing right-hand semicircles of the cyclones impinge on the land. In such cases the situation of a ship becomes, if possible, still more critical, and greater difficulties are likely to arise than in either of the instances already considered. Both in America and on the western shores of India, portions of the left and right-hand semicircles respectively interpose between the coast and the centre, while the storm is moving more or less in a parallel direction with the land, so that a ship by putting to sea may be able to get into the opposite semicircle, or obtain a good position in the one in which she is, and wait for the passage of the cyclone; but on the eastern shores of India the hurricane is often, if not always, coming down upon the land, and thus rendering it a most difficult manœuvre for ships near the axis-line to avoid the centre, or to get clear of the violent winds and terrific cross-sea in its neighbourhood. Much in a case of this kind depends on the knowledge and judgment of the commander, in order that such a course may be adopted as shall increase the distance of the ship from the centre, if possible, on the port side of the storm; but this is not always to be accomplished, for, on the usual signal being given, and the ships standing to sea with such a wind that they can only be placed on the *port tack* by which they sail toward the centre, the wind in the right-hand semicircle at the same time veering eastward, so that as they "fall off" their stems are pointed "on shore;" the point of greatest consequence is to take the earliest opportunity to "wear ship," and place them on the *starboard tack*, so that they may stand to the

The eastern coast of India a lee-shore.

Difficulties likely to arise in consequence.

Ship on port tack.

To wear ship.

north and north-east clear of the coast and centre. There can, however, be no question that such a position is both critical and dangerous.

159. While the advancing quadrant of the right-hand semicircle, indeed the entire winds of the *northern half*, as Col. Reid remarks, occasions that to be a *lee-shore* over which they sweep,—the winds of the left-hand semicircle or *southern half blow off shore;* so that in any roadstead, when this is perceived, the immediate course to pursue is to take advantage of these *off-shore winds*, put to sea, gain a good offing, ascertain the course of the storm, and so manœuvre that the centre may pass at a convenient and respectful distance.

Taking advantage of off-shore winds.

160. These off-shore winds may not only be taken advantage of to get a good position in a storm; they may also be turned to account in making expeditious passages to localities situated higher in the Bay during the prevalence of the N.E. monsoon. Much, of course, will depend on the position of the ships desirous of making such passages, especially with regard to the centre. The further they are removed from it, the greater the advantageous sweep. In such a manœuvre the barometer is invaluable, as advertising the commander of his keeping on the circle he designs to profit by. Captain Miller of the Lady Clifford, by adopting such a course as now alluded to, sailed from Nagore to Madras in about sixty hours, at a period when, under other circumstances, the voyage would have been a tedious one.

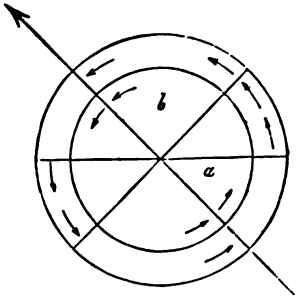
Ships overtaken by cyclones,

161. Vessels bound to the Indian ports may be overtaken by cyclones, and in such cases the hurricane winds they experience are those of the advancing quadrant of the right-hand semicircle—generally from the eastward. Mr Piddington advises, with northerly winds, a short run to the S.W. sufficient to raise the barometer, and to assure the seaman that he is out of the way of the violent parts of the storm; and then, as the wind hauls against the sun, to sweep round

to sweep round the

left-hand semicircle.

Fig. 36.



until he finds himself on the eastern border, so that he can "regain his lost distance without straining a rope-yarn." This manœuvre is somewhat similar to the one recommended for vessels sailing to North America (see section 149), and the same caution as there given is also necessary here, when the ship is overtaken by the most dangerous quadrant. The difference between the two manœuvres consists in the greater sweep to be taken in the Bay of Bengal, from right to left, before the vessel meets with a fair wind. The different winds themselves which the ships encounter, are also to be taken into account. In the Atlantic, under the circumstances mentioned in section 149, the S.E. to S. winds are those with which the commander has to manœuvre. In the Bay of Bengal they are N.E. to E. If, however, the commander find, upon his falling in with the hurricane, that he is not far in advance of the radius at right angles to the axis-line (see fig. 36), his wind being S.E., or nearly in that quarter, so that the cyclone is not bearing down upon him, his best course is to lie-to, if necessary, and allow the fair wind to overtake his vessel.

Vessels from India meet the most dangerous quadrant.

162. Vessels returning from India will generally meet the hurricanes on the most dangerous quadrant, their course being more or less towards the centre; and here the commanders are called on to exercise, to a very considerable extent, their judgment and ability, as, from the respective courses of the storm and vessel, it may often—should it be deemed desirable to wait on the cyclone—be difficult to put the ship in such a position that, when hove-to, she may experience as little as possible the violence of the wind. In the north-eastern part of the Bay of Bengal especially, no

little address is requisite, for, as the *receding* quadrant of the right-hand semicircle sweeps over the Birman coast, a lee-shore is created in the rear; while in advance of the centre, as the cyclone comes up towards Calcutta, a lee-shore is produced by the *advancing* quadrant on some portion of the coast extending from Chittagong to Balasore; in fact, the entire head of the Bay is more or less surrounded by lee-shores as a cyclone sweeps over it, and that portion of the storm which, even under ordinary circumstances, is the most unfavourable, becomes still more dangerous as the S.E. winds blow on shore. To put the ship on the starboard tack is out of the question. On the port tack, she not only approaches the centre, but as she "falls off," her stem is pointed on shore (as off the Coromandel coast, see section 158). In the head of the Bay she has not the opportunity to "wear," for as the wind veers to S.W., the coast in the neighbourhood of Chittagong becomes a lee-shore. Towards the south-east there is a great similarity between the Birman and Malabar coasts, both being lee-shores to the receding quadrants of the right-hand semicircles, and requiring somewhat similar management. In the case of cyclones moving westwardly, the left-hand or southern semicircle creates a lee-shore.

The Birman coast a lee-shore.

Difficulty of manœuvring in the head of the Bay of Bengal.

163. There is, perhaps, no locality in the world in which a ship may be placed in more imminent danger, when overtaken by a cyclone, than the head of the Bay of Bengal; if she be caught in the northern verge, two circumstances operate to place her on the *port tack;* the lee-shores surrounding her, and her course being to the southward, her head is consequently directed towards the centre, and, by standing on her course, in the great majority of instances she plunges more deeply into the storm, until, obliged to shorten sail, she rounds-to at a point in which she is placed in a most perilous situation. Her meeting the gale in the most dangerous quadrant, under circumstances that render it very difficult to heave-to—certainly on the right tack—appears to indicate

Head of the Bay of Bengal a dangerous and critical locality.

the propriety of taking the earliest advantage of the meteorological appearances,—"the barometer of signs," as Mr Piddington characteristically terms them,—to determine the proximity of the cyclone; to watch for some unmistakeable evidence thrown off by the disc, of its crossing the track of the ship; and with a sharp look-out, this will generally be in time for the vessel to run from the right to the left-hand semicircle, and get into a fair wind for the prosecution of her voyage, provided she be sufficiently removed from the shore to make the circuit. If this should be impracticable, the course adopted must be determined, in most instances, by the amount of sea-room she may have, and when circumstances will allow, she should be put on the *starboard tack*, that she may gradually leave the centre of the storm.

Ships to run from right to left-hand semicircle.

164. The following remarks bearing upon the meteorological indications of approaching storms in the neighbourhood of Calcutta and lower Bengal, also at Ceylon and the Andamans, are from "Rosser's Law of Storms," pp. 96 and 97:—

"I. Cyclones in the bay are preceded by a very moist and stormy wind from S.W., W.S.W., or W., to the south-westward of the place where they take their rise.

"II. Over that part of the bay where they originate, and before their formation, the barometer stands *lower* than ordinarily, and lower than on the coasts around the bay.

"III. This depression is generated at the time when a small general fall of the barometer occurs over the bay and gulf, such as frequently, and at all seasons of the year, interrupts its normal state—or, in other words, during the passage of an ordinary barometric wave.

"IV. A general incurvature of the southerly current around the place of low barometer precedes the formation of the centre of a cyclone.

"V. At the place where the centre is forming, the barometer falls still more than around the centre, and continues to fall while the cyclone acquires strength.

"VI. The incurving S.W. current being the principal feeder of the cyclone, and the centre being formed more or less towards its western border, the weather to the east and north-east of the cyclone is more tempestuous than to the west and north-west of it.

"VII. Within and around the cyclonic centre there is a strong indraught of the aerial currents, so that their direction is a spiral, not a circle, but more approximating to a circle at less than 10 to 15 miles from the centre than at a greater distance."

The following are applicable to Calcutta and lower Bengal, and refer principally to the barometer :—

"VIII. If, during the ordinary (tropical) periods of rise, the barometer is stationary or low, or if it falls more than two-tenths of an inch during the usual period of falls, bad weather is approaching.

"IX. If the wind blowing from S.E. changes to N.E. with a falling barometer, bad weather is probable. The barometer and indications of the weather must then be carefully watched.

"These signs should be especially noted at the coast stations, and warning given. The sea affords another very useful indication—when a strong swell comes in with gentle E. or N.E. breezes.

"The following indications at Ceylon and the Andamans ought to be particularly noted at the periods of change of monsoon.

"X. At Ceylon a stormy moist wind from S.W. or W.S.W., with clouds passing rapidly in the same direction, and the barometer falling, indicate a current which will probably produce bad weather in the bay.

"XI. When at Ceylon there are indications of a cyclone in its vicinity, there is but little probability of its reaching the north part of the bay, but it will probably be felt along the coast of Madras.

"XII. If at the Andaman Islands or Alguada Reef, or elsewhere on the Arracan Coast, after some days of gentle or variable winds, with a falling barometer, a moist and stormy wind from S.W. arises, the great probability is that there will be bad weather in the north part of the bay."

Cyclones moving towards the equator modify the phenomena experienced.

165. The occurrence of cyclones in the Bay of Bengal moving *obliquely from the pole to the equator*, although rare, will modify the phenomena as specified above. In the only instance of a hurricane having been first encountered in the central portion of the Bay, its motion was such as to convert nearly the whole of the winds of the advancing quadrant of the left-hand semicircle of a cyclone moving towards the north-west into those of the advancing quadrant of the right—*the most dangerous;* and in the liability of cyclones to move obliquely towards the equator in this locality, and also in the China Sea, we have another strong and urgent reason why commanders should determine in every case for

themselves the direction in which the cyclone may be moving. In the case now under consideration, the winds from N.N.W. to E.N.E. haul *with* the sun, the changes being very different from those of the same winds if the cyclone had been pursuing the usual course in these seas. A vessel sailing into the left-hand semicircle of an ordinary hurricane, and meeting the wind at north, upon heaving-to would find it veer to N.W. increasing in force, the barometer falling; but when the cyclone moves towards W.S.W., the changes are to N.E. and E.N.E., also increasing in force, barometer falling.

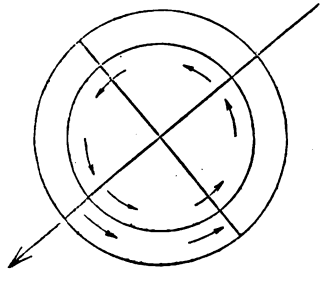
Different hauling of certain winds according as cyclones move from or to the equator.

As in the numerous examples under the head of "*Application of the Combined Results of the Progressive and Rotatory Motions of Cyclones*," page 24, it was shewn that the hauling of the wind *with* or *against* the sun, determined not only the position of the vessel in the storm, but also the direction in which the cyclone was moving; so the hauling of the particular winds in the instance before us at once settles the question as to whether the hurricane be moving to or from the equator.

The comparative frequency of cyclones moving *obliquely from the pole to the equator*, in the Bay of Bengal and China Sea, may render the following paragraphs essential, as supplementary to the "*Application of the Combined Results of the Progressive and Rotatory Motions of Cyclones.*"

HURRICANE moving towards the S.W.—SHIP in the right-hand semicircle.

Fig. 37.



Hurricane moving S.W., ship in right-hand semi circle.

166. A ship in the right-hand semicircle of a cyclone, moving towards the S.W., will experience winds varying from N.W. by N. to N.E. increasing in force, and winds varying from N.E. to S.E. by E. decreasing in force. These winds haul with the sun.

HURRICANE moving towards the S.W.—SHIP in the left-hand semicircle.

167. A ship in the left-hand semicircle of a cyclone, moving towards the S.W., will experience winds varying from N.W. by W. to S.W. increasing in force, and winds varying from S.W. to S.E. by S. decreasing in force. These winds haul against the sun. Hurricane moving S W., ship in left hand semicircle.

Upon comparing these winds with those mentioned in sections 32 and 33, hurricane moving towards the N.E., northern hemisphere, and those mentioned in sections 36 and 37, hurricane moving towards the S.W., southern hemisphere, they will be seen to be exactly the opposite—a state of things naturally arising from the combination of the rotative and progressive motions in the two hemispheres.

When vessels fall in with cyclones moving towards the S.W. in the Bay of Bengal and the China Sea, the barometer will fall with N., N.W., and W. winds, and rise with E., S.E., and S. winds.

THE CHINA SEA.

168. Vessels bound to Canton and Macao generally sail into the most favourable quadrant of a typhoon, the receding of the left-hand semicircle; indeed, they usually meet the typhoons in the same manner as vessels in the Arabian Sea and Bay of Bengal, that are bound to Bombay, Madras, and Calcutta, and by simply waiting or lying-to, all the dangers are avoided; or the manœuvre of sailing with the hurricane winds round the heel of the storm so as to fall in with the fair winds of the receding quadrant of the right-hand semicircle, as recommended under the heads of "Arabian Sea" and "Bay of Bengal," may be adopted with advantage. If, however, the typhoon overtake the vessel, so as to involve it in the most dangerous quadrant of the right-hand semicircle, the commander must generally be guided by his proximity to the land or other important and essential considerations, as to whether he shall or shall not adopt a similar course to Vessels to Canton meet the typhoons in the most favourable quadrant.

Ships overtaken by the right-hand semicircle of a typhoon.

that which would be desirable either in the Arabian Sea or the Bay of Bengal; for it must be remembered, that while the coast of China is a lee-shore as well as the eastern coast of India, and from the same cause, yet the lee-shores in the two instances of the Arabian and China seas are vastly different. In the Chinese seas, the winds contributing to the existence of a lee-shore in China are those of the *advancing* quadrant of the right-hand *semicircle*, indeed the right-hand semicircle generally, and not those of the receding quadrant only, as in the Arabian Sea. There are two considerations that appear to be important in determining the course to be adopted—the track of the vessel, and the proximity of a lee-shore. Consequently, if a vessel be overtaken by the right-hand semicircle near the shore, with the wind at S.E., she must bear away to the S.S.W., take the earliest opportunity to wear, and avail herself of the tail winds of the hurricane to bring her into port.

Lee-shore in China.

169. The geographical configuration of the China Sea, combined with the great range of hurricane-paths in its locality, occasion the lee-shores to be very diversified. In the neighbourhood of Canton and Macao they are mostly of the same nature as those in the Bay of Bengal in the neighbourhoods of Cuttack and Coringa, the hurricanes coming directly down upon the land. When, however, the cyclones move *obliquely from the pole to the equator*, they are of precisely the opposite character to that of the lee-shores produced on the coast of the United States—*i.e.*, the lee-shores in the United States are created by the advancing quadrants of the left-hand semicircles, while those in China result from the receding quadrants of the right-hand. The winds, however, are precisely the same, viz., S.E., but with this important difference: in America they are succeeded by the "off-shore" winds, in China the "off-shore" winds come first, and thus furnish commanders with an admirable opportunity of putting to sea in time, crossing in front of the axis-line, and

Lee-shores of the United States and China.

sailing round the left-hand semicircle, if the cyclone be not too large for the manœuvre. Under almost any circumstances, a putting to sea with the "off-shore" winds will enable the commander to take up a good position with regard to the centre of the storm. The lee-shores of Cochin-China are almost without exception of a similar nature to those of the Coromandel Coast.

Vessels leaving China experience similar phenomena to those leaving Calcutta.

170. Vessels leaving China will generally meet the typhoons much in the same way as ships sailing from Calcutta fall in with the hurricanes of the Bay of Bengal, viz., on the advancing quadrant of the right-hand semicircle. The typhoons also bear down directly on the land, as is the case with the Bengal hurricanes, and the same difficulties arise in both instances. We would here reiterate the immense importance of much skill and judgment, with a competent knowledge of the "Law of Storms," being brought to bear on these complicated and trying circumstances. The general rule is, put the ship on the starboard tack in the northern hemisphere, and she will draw from the centre; but in the four instances of the Arabian Sea, the Bay of Bengal, and the China Sea, put the ship on the starboard tack, and she will draw to the *lee-shore*. Again, in these instances, put her on the port tack, and she will draw to the centre. Great skill is consequently requisite to avoid the dangers on either side.

Difficulty of putting the ship on the starboard tack.

Localities.

The localities and storm areas in which these difficulties arise, are as under:—The Arabian Sea, Malabar coast, receding quadrant of the right-hand semicircle. The Bay of Bengal, Coromandel coast, advancing quadrant of the right-hand semicircle, or generally the right-hand semicircle. Head of the Bay of Bengal, right-hand semicircle. Bay of Bengal, Birman coast, receding quadrant of the right-hand semicircle. China Sea, the coast of China, right-hand semicircle.

171. In the case of vessels likely to be brought into these critical situations, too much attention cannot be bestowed on the meteorological signs attendant on and prognosticative of

hurricanes; it may frequently occur, in situations such as have just come under our notice, that the ship may be too much involved by the time the direction and hauling of the wind announce her position in the storm; and here we see the great importance of studying the atmospheric appearances. They announce at a very early stage, so far as the ship is concerned, the direction in which the cyclone is raging; and according as the ship's course is shaped, so the commander may judge whether he is approaching it on the axis-line or on either of the semicircles. It is highly probable that a very early attention to the significant appearances in a certain quarter of the horizon, and an alteration of the ship's course in consequence, may prevent many disastrous results that would otherwise occur if the same steps were taken as in ordinary circumstances. It is also important, in connexion with the meteorological signs, to notice the direction of the storm-wave; both may very materially assist in determining what shall be done.

Great importance of noting the meteorological signs of cyclones.

The direction of storm-waves should also be noticed.

THE INDIAN OCEAN.

172. In the chapter on storm-paths, two very essential characteristics of the tracks in the Indian Ocean were pointed out: the probability of the contemporaneous existence of two or more cyclones in the Indian Ocean, and the coincidence, extending over 30 degrees of longitude, of the line of recurvature with the tracks of vessels from India and China to the Cape or Europe (see sections 106 and 107). The return voyage in the Indian seas thus lying, as it were, in the very heart of the hurricane region, the phenomena exhibited will claim our first attention. It very seldom happens that a commander falls in with a cyclone until he has fairly entered the S.E. trade, and during the hurricane season he should be constantly on the look-out—especially if he be within the meridians of 50° and 90° east, and near the 30th parallel; or, generally speaking, near the line of recurvature

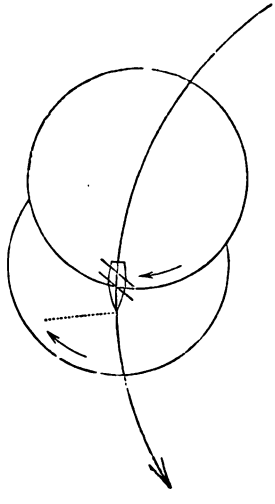
Phenomena on the return voyage from India.

(see section 106)—for the slightest change of weather, and the earliest appearance of a swell, noting particularly the direction from which it comes, as these appearances may be very significant. If, while bowling along at a steady rate, with a brisk S.E. trade, he finds its character now and then change, the meteorological signs before described making their appearance, and the swell gradually becoming higher and more troubled, there can be no doubt that a cyclone has overtaken him, although the state of the wind and weather may be such as to cause no particular apprehension or alarm. He is on its S.W. margin, and its centre is rapidly bearing down upon him. There are, under these circumstances, two modes of action open to him,—either to bear away to the N.W., and get into fine weather, or to stand to the S., and look out in these longitudes for the bend or recurvature of the storm. In most instances the last manœuvre is the best to be adopted; the commander departs less from his usual course, and it is probable he may avoid meeting with a contemporaneous cyclone which may be raging to the N.W. He must, however, keep a sharp watch on the wind, noticing minutely every change; for should the hurricane, while he stands to the S., get so much westing as to arrive at his meridian, *i.e.*, the meridian of his ship, by which he experiences an easterly wind, and this hangs instead of continuing to haul with the sun, he can come to no other conclusion but that the cyclone is recurving, and of course in his new position bearing down upon him. His course now being on the southern verge, with an easterly wind, is to stand to the west,

Indications of a vessel being on the S.W. margin.

The commander standing to the south to avoid bad weather.

Fig. 38.



The cyclone recurving, and again bearing down upon him.

by which he soon improves his position, the distance between his ship and the storm's centre rapidly increasing, in fact they are moving in different directions. (See fig. 38.)

173. A commander, however, may not always be so favourably situated. The hurricane may make westing of him, and instead of his being on the southern verge, he may find himself on the south-eastern, with the wind at N.E., fig. 39. In this case the wind, though favourable for his voyage, will plunge him into the vortex; for the increasing bad weather, with symptoms of the wind hauling to N., acquaint him with the fact of the cyclone having paused in its course, and that its recurvature has arrived. Here he has to wait or even stand a little to the east, that the hurricane may get sufficient southing to allow him to cross its wake, which he may do with comparative safety when he gets N.W. winds, as the centre will then be to the S.W. of him, see fig. 40, in which C represents the centre of the cyclone to the S.W. of N.W., his hurricane wind.

Fig. 39.

A ship on the south-east verge,

the commander standing east and waiting.

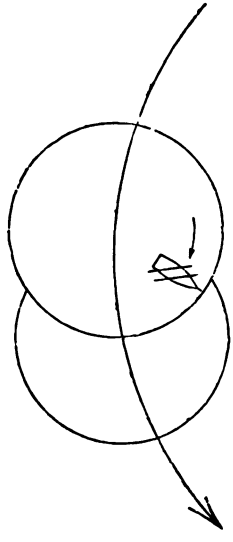
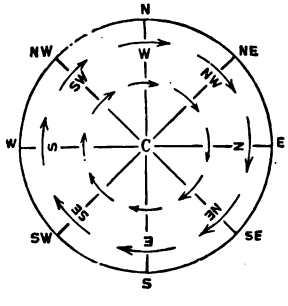


Fig. 40.



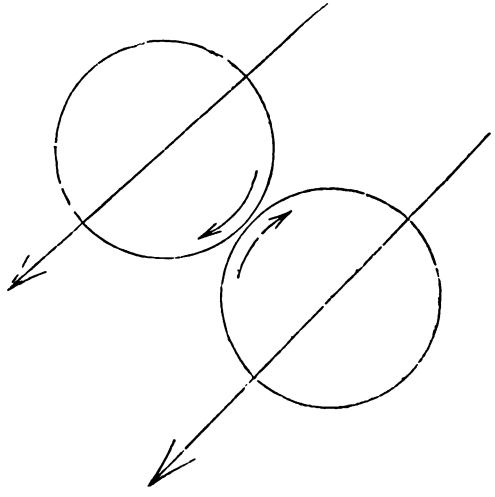
174. In the last instance, as well as in that of his bearing away to the N.W. to avoid bad weather, a commander should look out that he be not puzzled by meeting with winds he may not expect, for if a cyclone be moving either to the west or north-west of him, instead of again falling in with a steady

A commander may meet with unexpected winds in crossing to the N.W.

S.E. trade, he may experience precisely the opposite wind to that which he has just left (see fig. 41), with a remarkably

by falling in with a second cyclone.

Fig. 41.



high state of the barometer. In such a case as this, the precise mode of acting must be determined by the circumstances in which a commander finds himself placed; in the great majority of instances it would probably be better to wait on the second cyclone, until it had attained sufficient southing to allow of its receding semicircle being crossed.

Propriety of waiting on it.

175. If the hurricane overtake the ship with an E.S.E. wind on a meridian which would lead the commander to consider that the cyclone would pursue its usual W.S.W. course, and he heaves-to or stands to the south, in order that the cyclone may get westing, instead of which the bad weather rapidly increases, and the wind hangs at east, he has a most significant indication that the storm has recurved, and is bearing down upon him. The great object he must now have in view is to make, as quickly as possible, a good westing, and get as near the right-hand margin as possible. One of the worst positions a ship can be in, is to remain hove-to with a hanging wind, as, under such circumstances,

Cyclone overtaking the ship with E.S.E. wind and recurving

with a hanging wind at E., the ship to make westing,

and not to remain hove to.

the centre is surely and rapidly approaching her. It would be even better to put her before the wind, and let her describe an octant, by which she brings the centre of the storm to the N.E. of her, and has the wind S.E. (see fig. 40), a position from which she can more easily extricate herself, than to remain lying-to with the centre coming down on her, while she is exposed to all the fury of the storm.

Ship meeting a cyclone with the E.N.E. *hanging* wind to pursue her course.

176. There is still another position in which the cyclone and ship may meet; it is when, after recurving, the hurricane progresses towards the S.S.E., and takes the vessel with an E.N.E. wind. The hanging of this wind, with increasing bad weather, will soon announce the bearing down of the hurricane on the ship, and it is easy to see that if the ship pursue her usual course, she will soon lose the violence of the wind as she is gradually receding from the axis-line.

Ships sailing into the northern semicircle to make westing or to lie-to.

177. The above remarks have reference to vessels falling in with cyclones on their southern margins, which, of course, are the most unfavourable and dangerous portions of the storms both to homeward and outward bound vessels. But little need be said on vessels sailing into the northern semicircle; in nearly all cases a standing to the westward, if possible, will quickly relieve them, and when this is impracticable, simply heaving the ship to will allow the hurricane to get southing. We have already noticed the probability of meeting on this side of a cyclone with a second. As the phenomena resulting from the proximity of neighbouring hurricanes require further elucidation, all kinds of evidence on this head will be of great importance.

Ships sailing into the northern semicircles may meet

178. While, however, the hurricane winds of the northern verge, being in the receding semicircle of a storm, is sufficiently indicative of their harmless nature, yet the commander himself can readily convert them into winds of the most dangerous character, by standing on when sailing into the northern semicircle, especially if he be in advance of the right-hand radius at right angles to the axis-line—*i.e.*, with

winds *southward of west.* Every knot he runs he depresses his barometer, and increases his bad weather; his wind veers to west as the cyclone passes his meridian, and if it pause in its course—a contingency very likely to happen in the neighbourhood of the line of recurvature (see fig. 30)—it is not at all improbable he may plunge himself directly into the centre. In a case of this kind, Mr Piddington strongly advises that the vessel should be put before the wind, or even to stand to the N.E., to raise the barometer. This manœuvre will bring the ship and centre on the same meridian, and when the wind hauls to northward of west, the vessel can be steered southward of east, gradually changing her course until the commander finds himself on the S.E. verge with a N.E. wind, or in the precise situation indicated in section 173. This would, as Mr Piddington observes, be a fair wind, and as long as the cyclone pursued a W.S.W. course, the ship could bowl along with it, making a good run; but unless the commander kept a sharp look-out for the earliest change in the course of the storm, and especially for the bend, he might, after all, be caught by the furious centre as the cyclone recurved; besides, by sailing half round the storm, he brings himself into a position that he must do one of two things—either cross in front of the cyclone, which he might possibly do if he had kept his barometer well up, or cross its track behind the centre, which in these localities is generally recommended. The practice of heaving-to, to allow the centre to get westing, Mr Piddington considers as a loss of time, as the ship, when bearing up, would soon overtake the cyclone, when it would be requisite to heave-to again.

with damage by the commanders standing on.

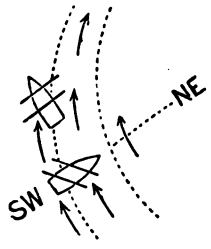
179. Outward-bound vessels meeting cyclones in the Indian Ocean, will mostly be guided by the semicircle into which they sail as to the measures to be adopted for avoiding the centres. In most instances they will sail into the left-hand semicircle, meeting the hurricane winds from S.E. to

Outward-bound vessels generally meet the left-hand semicircles of cyclones.

E., rendering it very tempting to run on; much caution, however, must be exercised as to crossing the storm's track, for if this be attempted with any of the winds above named and increasing bad weather, with a rapidly falling barometer, a commander may very soon find himself in the heart of the storm, from which it will be a difficult matter to extricate himself. Should the weather be very tempestuous at some distance to the left of the axis-line, a prudent course would be to wait on the cyclone until he can cross the *receding* semicircle with safety.

180. The phenomena described in this chapter are based entirely on the *circular theory*, and in applying them to any cases that may present themselves in either hemisphere, regard must be had to the directions given in sections 6 to 42 on "Circular, Incurving, and Spiral Storms." With the liability of sailing into either of these kinds of storms, it will be the first care of the commander to ascertain in which kind he is involved; figs. 3, 4, and 15 will greatly assist him in ascertaining this primary point. It would take up too much space to specify the phenomena for each kind of storm in every locality, but we select one as applicable to the last section. A ship sailing to Calcutta, and meeting a spiral storm coming from the N.E., instead of falling in with a S.E. wind, as in a *circular* storm (see fig. 40), she would meet with a S.S.E. or S. by E. wind, see fig. 15, p. 35. With these winds upon the *circular* theory, the centre would bear *eight* points, or E.N.E. or E. by N.; but on the *spiral* it would bear 10 or 11 points from the wind at the ship, or N.E. If the ship pursue her course towards the N.E., the centre bearing down upon her from that quarter, she would find either the S.S.E. or S. by E. wind to *hang*, with barometer falling and the weather getting worse, which would advertise the commander of his plunging into the vortex. Upon the rotatory theory he would be on the W. by S. margin, but on the spiral he would be on or near the S.W.

Fig. 42.



margin. Now, from the course he is steering, he knows he must be near the S.W. margin, and therefore, by combining his *hanging* wind and *course*, he would find no difficulty in knowing the kind of storm he is in—viz., a spiral. Having ascertained this point, his next step is to get out of it. It is clear he cannot "carry on"; his hanging wind, increasing bad weather, falling barometer, and tack when sailing into a hurricane—viz., the starboard—see fig. 25, p. 47—forbid him doing so; he should therefore alter his course, so that he may get northing and westing to allow the spiral to cross his meridian as far south as possible. When he arrives at the parallel of the central vortex, he will see from fig. 15 that the incurvature is very decided, and the further he stands to the N.W. the better, in order to avoid the N.W., N. and N.E. winds, which draw round rapidly to the vortex. By this manœuvre the destructive E. and S.E. winds will be situated to the S.E. of him. His barometer and weather will guide him as to when he can proceed on his voyage.

CHAPTER VIII.

ATMOSPHERIC WAVES, CYCLONIC AND ANTI-CYCLONIC SYSTEMS.

181. Since this work was first issued in 1853, considerable progress has been made in Meteorological knowledge; a few years prior to its publication, Professor Dove of Berlin had suggested that the great aerial currents of Western Europe were arranged side by side as two oppositely directed streams of air, one blowing from the S.W., its companion current from the N.E. with a shifting motion from N.W. to S.E. In an investigation into the nature of these currents, the author of this work ascertained the existence of another set of winds of a somewhat similar character, which blew from N.W. and S.E., having a shifting lateral motion towards the N.E. Somewhat similar parallel beds of air, blowing in opposite directions, have been found in the southern Indian Ocean. In the northern hemisphere, during the lateral passage of the N.E. and N.W. winds towards the S.E. and N.E., the barometer rises; and as the S.W. and S.E. winds pass on in a similar manner towards the S.E. and N.E., the barometer falls—each of these sets of parallel currents of air blowing in opposite directions constitute "an atmospheric wave;" and as the barometer rises with one current and falls with another, it follows that, on the boundaries of the two oppositely directed currents, the barometer stands alternately *highest* and *lowest*—highest when the N.E. or N.W. currents give place to the S.W. or S.E., and lowest when the S.W. or S.E. currents give place to the N.E. or N.W. The line of *highest* barometer is called the *crest* of an atmospheric wave, the line of lowest the *trough*, in which at particular seasons, and under certain influences, the streams of S.W. and S.E. winds may attain, in the open ocean, such a velocity as to amount in

Nature of atmospheric waves.

Under certain circumstances the winds of atmospheric waves may attain the intensity of hurricanes,

intensity even to that of a hurricane; for the great violence of the hurricane winds arises entirely from the immense velocity of rotation. It might at first be apprehended that these streams, the troughs of atmospheric waves blowing more or less rectilinearly, would not be attended with such serious consequences when ships cross them as we know arise from hurricanes; but when it is considered that the commander in such cases has no warning, from the shifting of the wind,—he is, in fact, much in the same position as if he were on the axis-line of a cyclone, and, so far as we yet know, without the means of receding from it; that when the change of wind occurs, he is in the greatest danger of being taken aback as it springs up from the opposite quarter *without the intervention of a calm.*

and be attended with similar serious consequences.

182. It is in the points at which atmospheric waves cross or intersect that cyclones and storms of all kinds are generated. These have been so fully discussed in the foregoing pages as to need no further notice, but the word cyclone has of late years received a more extensive signification than it had when first applied to designate the severe Atlantic Storms. On turning to Chapter III., fig. 27, the reader will find that within the area of a cyclone the barometer is depressed; the word cyclone is therefore not only used to signify a destructive storm, but any barometric depression, large or small, deep or shallow. If a depression be very extensive, and at the same time shallow, the height of the barometer will vary but little over its area. It may be 480 nautical miles in diameter, and depressed in its centre a quarter of an inch. The slopes of the depression would thus extend from circumference to centre over 240 nautical miles; but the fall and rise of the barometer would not be equal while a ship was passing through a depression of this nature. Let us take the fall for every 60 nautical miles of the first semi-diameter, and the rise for the second as follows:—

Extended signification of the word cyclone.

Barometric depressions.

Miles.	Fall in inches.	Miles.	Rise in inches.
The first 60	0·0625	240 to 300	0·050
60 to 120	0·0375	300 „ 360	0·075
120 „ 180	0·0250	360 „ 420	0·025
180 „ 240	0·1250	420 „ 480	0·100
	0·2500		0·250

Gradients.

The fall or rise of the barometer during the passage of a ship over 60 nautical miles is called a "gradient," and these gradients are of different values; the smallest fall in the above table is 0·025 inch, between 120 and 180 miles, and the greatest for the next 60 miles is 0·125 inch. In the first the force of the wind is least, in the second greatest; for it has been ascertained that the steeper the gradient the greater the force of the wind, which in a cyclone often blows in directions parallel to the *isobars* or lines of equal barometric pressure. When the isobars are far apart, the wind is light, the gradients being of slight inclination; but when they are crowded, the gradients are steep and the wind strong.

Anti-cyclones.

183. Wherever an area of low pressure or a barometric depression exists, there is somewhere an area of high pressure; such an area of high pressure is called an anti-cyclone, in which the winds are very light; the height of the barometer is generally above its mean, and the wind circulates in a direction contrary to that in which it circulates in a cyclone. The phenomena are quite opposite to those of a cyclone, and hence the name anti-cyclone.

ADDENDA.

CONSIDERABLE stress has been laid in the foregoing pages on the fact, that revolving storms originate either in, or near the borders of, zones precipitating aqueous vapour. Some years since, Mr Thomas Hopkins of Manchester published a work on the atmospheric changes which produce rain, wind, and storms, in which the author strongly insists on the hypothesis, that heat liberated by the condensation of aqueous vapour (designated by Mr Hopkins steam) is fully adequate to produce the most violent disturbances of the atmosphere. In connexion with this view, it is not a little remarkable that all great revolving storms should originate in localities of the kind specified. Mr Hopkins' view does not appear to be without foundation, for Professor Dove of Berlin has determined a most important meteorological fact from thermometrical observations made at more than 800 stations on the surface of the globe, viz., that the whole globe possesses a higher temperature in July than in January, the difference being fully 8° of Fahrenheit's thermometer. The hypothesis submitted by Mr Hopkins furnishes the only means of explaining this higher temperature at a season when the earth, by reason of her elliptic orbit, is further removed from the sun; and we accordingly find Professor Dove referring to this very principle in his remarks on the results of the observations above alluded to. He says—"When, therefore, the sun, returning from its northern declination, enters the southern signs, the increasing proportion of liquid surface upon which it shines causes a corresponding part of its heat to become latent, and hence arises the great periodical variation in the temperature of the whole globe, which has been noticed above." Again—"The non-symmetrical distribution of land and sea in the two hemispheres, necessarily causes

the aqueous vapour, which is developed in a preponderating degree over the southern hemisphere, from the autumnal to the vernal equinox, to return to the earth in the form of rain or snow during the other half of the year. Thus the wonderful march of the most powerful steam-engine with which we are acquainted—the atmosphere—appears permanently regulated by laws of periodical action." And further—"It is probable that the northern hemisphere acts as the condenser, and the southern hemisphere as the water reservoir, of this steam-engine; and thus that a greater quantity of rain falling in the northern hemisphere is one cause of its higher temperature, since the heat which became latent in the southern hemisphere is set free in the northern in heavy falls of rain."*

There are evidently two sources of wind both referable to an increase of temperature, by which the air, being rendered specifically lighter, ascends to the higher regions of the atmosphere; one of these sources consists in the heating power of the rays of the sun, which, shining directly on the terrestrial surface, raises the temperature of the air, and causes it to ascend. The other source is to be found in the condensation of aqueous vapour (steam), which, in the opinion of Mr Hopkins, gives out so much heat, that a powerful ascending current is produced, when a surface wind more or less strong rushes in to supply the rising column.

The accuracy of this latter view future observations, especially in such localities as Mr Hopkins refers to, will doubtless decide; in the meantime the great meteorological principle of an increase of temperature from the condensation of aqueous vapour, is, we apprehend, fully established; and from this it follows as a corollary, that the air must be

* Prof. Loomis, in his "Summary of Weather Laws," says, "If the rain area has great geographical extent, it may have a decided influence upon the amount of the barometric depression, and upon the velocity with which the storm advances."—See *English Mechanic*, Oct. 19, 1877, p. 135.

rendered specifically lighter, and will, in consequence, ascend. Guided by this clue, we may, before finally closing our volume, again refer to the production of the revolving storm. That the simple condensation of aqueous vapour, and its precipitation in rain, are not of themselves, at least in their earlier stages, sufficient to induce the rotation, is clear from the fact, that in the case of the West Indian hurricanes, it is only towards the close of the rainy season that they make their appearance; if, then, they result from a powerful ascending current, supposed to be induced by the liberation of heat during the process of condensation, some other inducing cause must be added to explain their appearance only at a certain season. On referring to the table in section 93, page 68, we find that most of the West Indian hurricanes originate when the sun is nearly vertical to the locality of their commencement. May we not have here a sufficiently powerful action in the continued heating of the atmosphere by the successive condensations that may be rapidly taking place in consequence of the verticality of the sun? All that appears to be requisite for the production of a revolving storm, is the rapid disengagement of heat, by which a large body of the atmosphere ascends with such a velocity as to induce a rotation, when the centrifugal force depresses the interior portions of the cyclone, and the colder air descends. The immense velocity of rotation tends greatly to commingle the atmosphere within, without, and above the annulus or ring of the revolving air, and thus the condensation proceeds, the liberated heat continually urging upwards the ascending column within.

The cyclones of the Bay of Bengal occur in the month of May under precisely similar circumstances. The south-west monsoon is characterised by very copious falls of rain, and these falls appear to be fully established when the sun becomes vertical to the Bay. There is, however, one important point to mention—viz., the West Indian hurricanes

occur towards the *end* of the rainy season, but the cyclones of the south-west monsoon not long after its commencement. Is this difference explained and harmonized by a reference to the *quantity* of rain, and therefore to the *rapidity* of the condensation? In immediate connexion with this, we may notice that the mean temperature of the West Indies, Barbadoes, and Jamaica, is about 81° during the hurricane month of August. On the Coromandel coast, Pondicherry, it is about 94° and 95° in the cyclone months of May and June. In both cases these temperatures are about the maxima of the year. Mr Hopkins refers to the *strength* of the wind in the south-west monsoon bearing a constant relation to the *amount* of rain.

The probability of the north-east and north-west monsoons (both occurring at the same season) constituting but one stream of air, is referred to in Mr Hopkins's book—the Indian Archipelago determining the condensation of the vapour, and giving rise, in a great measure, to the rainy season in the north-west monsoon. At the time of the prevalence of cyclones in the Bay of Bengal during the north-east monsoon, the sun is south of the equator, and in this particular instance the foregoing reasoning appears to fail; it may, however, be remarked, that the hurricane paths are more westerly, and there is some reason to believe that *the formation of cyclones is not confined to the surface of the ocean, but takes place also in the higher regions of the atmosphere—the discs, in a state of rotation, settling down upon the sea.** If this be the case, a cyclone may be formed, by

* The position of a ship under these circumstances is very critical, inasmuch as by a cyclone "settling down" the vessel may be suddenly involved in the most terrific part of the storm, with her head directed towards the centre, and the hurricane wind such as to place her on the wrong "storm tack" if she continue her course. The commander, knowing the bearings of the centre and margin, will take such measures as may be necessary to improve his condition —his barometer being his faithful guide. There is no doubt this instrument will, in all such cases, give notice of the descending whirlwind by a most *rapid fall*, accompanied by very remarkable meteorological indications.

means of the same agencies as above-mentioned, at a considerable distance from the locality in which it is first encountered. If, however, there be some difficulty in connecting the production of the cyclones of the Bay of Bengal during the north-east monsoon with the condensation of aqueous vapour, there is none in the case of those in the Indian Ocean,—they are coincident with the period of precipitation of vapour, with the sun more or less vertical to the hurricane region. In the China Sea, the same conditions are brought out, indeed, in so striking a manner, that the prevalence of cyclones in certain localities, as the sun moves southward, is exceedingly unmistakeable. The great similarity in some respects between the cyclones of the China Sea and those of the West Indies have been hinted at in the foregoing pages.

With the exception of the winter hurricanes of the Bay of Bengal, the evidence that the verticality of the sun is an essential element in the production of revolving storms, appears to be irresistible; and in framing any hypothesis to account for their origin, it must doubtless hold a very conspicuous and prominent position. The condensation of vapour has clearly much to do with the formation of cyclones; but it appears that, before the rotative motion can be induced, the condensation must be of a very energetic and even violent character. If a sufficiently powerful force, operating in the condensation of aqueous vapour, can be found, it is very probable all the phenomena of cyclones will follow as a matter of course.

On page 73, the hurricane which occurred in the month of March in the Bay of Bengal has been included in the south-west monsoon. It really occurred during the north-eastern, but being of an erratic character, so far as season is concerned, it has been classed with the spring and summer months.

In the practical application of the rules and remarks embodied in the foregoing chapters, the commander will have his

attention first arrested by the swell or storm-wave which strikes against his vessel. When no other sign of a cyclone is present, this will announce to him that in the direction from which it has advanced upon him a hurricane is raging. The sky may with him be clear, the air light, the wind favourable for his course, and he may crowd all sail to make a good, and probably an expeditious run. While thus proceeding on his voyage a storm-wave is not to be disregarded, although, when he first experiences it, the cyclone may be full three days' journey from him; he will notice if it change its direction, and he will particularly remark if by his run he has so altered his position with regard to its first direction, that he has reason to believe he is in the path of the cyclone, and that it is advancing upon him. Connected with the positions of the vessel and storm-wave, and especially combining these with the run since first experiencing the swell, the commander will remark if the wind has increased in force so as to occasion him to shorten sail even to a moderate extent. From the time he first noticed the setting in of the swell, his barometer will have closely occupied his attention; and especially if, while running so as to keep in the main line of swell, it should have *risen*, he will watch it more attentively and closely. Next to the swell, increase of wind, and state of the barometer, the banking of the clouds will engage his attention, and by this time it may not be unlikely that he has to take in a reef or two, especially if any loose scud be flying over his ship. The swell and cloud-bank combined will now shew him *where* his danger lies, and with these indications he cannot bestow too much attention on his barometer; for it may be that a swell in the northern hemisphere coming from the south-west, a heavy-looking bank of clouds in the same direction, and his barometer rapidly falling—all announce to him that to "carry on," although he may only be under double-reefed topsails, is pushing into danger. Before getting more deeply into the

storm, which will be indicated by the barometer continuing to fall, the bank approaching the ship, the cross-sea increasing, and the scud flying across the zenith, the commander may at once improve his condition by bringing the wind on his starboard quarter and edging away to the northward, by which he raises his barometer and shakes out his reefs. This may, as Mr Piddington remarks, be considered "a turning tail for a gale of wind;" but let us now watch the vessel as she runs to the northward and is relieved from the cross-sea, her wind at the same time becoming lighter. Being able to carry more sail, she may run before the wind at seven or eight knots, and make a good course to the N.W., during which she finds the wind to veer to E.S.E. and E.; while thus manœuvring, her great object must be to edge away towards the margin if she find the barometer falling. With an easterly wind she passes the meridian of the storm; and under the circumstances alluded to, will doubtless recognise all the significant signs of the hurricane more or less to the south of her. She is now well situated for pushing on, her only precaution being to edge away towards the margin that she may keep the barometer well up. If the storm has recurved, she has crossed the axis-line, and every wind she gets is favourable for her*; if the storm has not recurved, she has only to manœuvre in the same manner, keeping towards the margin until she has crossed the axis-line, and this the barometer will assuredly make her acquainted with; for by keeping on her course in the left-hand semicircle, she is rapidly leaving the centre—the barometer at the same time

* This has reference to a circular storm; but the commander will see, on consulting fig. 4, p. 9, and Table I., p. 12, that if he be involved in a spiral storm, the wind, as he edges away to the N.W., will rapidly veer to N. through N.E. (*see Table* IV., *foot-note* [10], *p.* 20); and as the N. wind is succeeded still more rapidly by a westerly wind leading directly to the centre or destructive vortex, his best course appears to be to make as much *northing* as possible, as the storm passes the meridian of his ship, the bearing of the centre being then eight points or south of him. For the dangerous character of the left-hand semicircle of a spiral storm, see foot-note [20], on p. 42.

rising.* If the manœuvre be executed in time, the "turning tail" is but sailing into a fair wind, and leaving the terrific centre to wreak its fury on the careless and unwary.

In the Indian Ocean, while passing through the trade during the hurricane season, a homeward-bound commander will be on the alert for the slightest change in its character; and, with a brisk trade, will notice if the swell be regular, and particularly if the horizon from the N. by the eastward to S.W. exhibit any indications of the formation of a cloud bank at the same time that the trade becomes puffy and squally; he will also particularly notice, while "standing on," the character of his weather; and, should its appearance become threatening, he will ascertain, by dodging now and then to the south, if by such a manœuvre his weather will improve, his barometer "keep up," and he can carry his to'gallant-sails. While so doing, he will remark if his wind veer to east, and also if its hauling be accompanied by a shifting of the cloud bank, so that, with E. and E.N.E. winds, the north and north-west exhibit the indications of the hurricane raging in those quarters. With a stiff breeze from E.N.E. on the S.S.E. verge of the cyclone, he may run about nine or ten knots, and while thus making up for his dodging to the south, he will again have his attention most sedulously directed to the weather, noticing the veering of the wind; and as its hauls to the north, should his barometer fall, and he be compelled to reduce his canvas, he will prefer "wearing,"

* In a spiral storm which has not recurved, and is therefore moving towards a point between N.W. and N., it would not be prudent for a commander to *cross the axis line* if he sail into the advancing quadrant of the right-hand semicircle with winds from E.N.E. and E.; for with the easterly wind the centre bears S. of him, and upon the opposite or southern side of the centre there is a stream of air rushing with violent force from the southward to the vortex. Under these circumstances his best course appears to be to wait, if practicable, on the starboard tack while the storm gets northing, and he is left in the posterior quadrant of the right-hand semicircle, the wind veering from E.S.E. to nearly S.; it may even be necessary to bear to the eastward as the wind veers to S., in order to keep the barometer well up as the storm and ship part company, so that she may resume her course without fear of being drawn by the violent southerly winds into the vortex.

so as to place his ship's head to the eastward, and as his weather improves, to wait on the hurricane while it gets southing of him. Experience has fully confirmed that an attentive consideration of all the indications of a hurricane, accompanied by a dodging to the south and east, while on its southern and eastern verge, have not been attended with loss of time, the facility with which commanders have manœuvred to avail themselves of favourable winds more than counterbalancing any temporary interruption of their course.

The object of these additional remarks is to solicit the attention of commanders to the combination of the earlier signs of hurricanes which have been treated separately in the body of the work, and especially to indicate that, if the recognition of the cyclone be deferred to some ten or twelve hours after the signs above alluded to have made their appearance, it may be much too late to attempt to sail round the front of the hurricane in the northern hemisphere, and get into a fair wind; or to dodge in the southern, and avoid its fury. There is only one instance in which it may be deemed impracticable to sail round the advancing front—it is when the cyclone may be very extensive, and in that case the sweep would be very considerable; but even here an early attention to the significant signs may enable the commander to cross in front of the centre at a safe distance; for, while the veering of the wind as he stood on would be but slow and gradual, and perhaps hardly sufficient to announce the presence of a cyclone, yet the state of the barometer and the quantity of sail he could carry would enable him to sail on a curved course, at such a distance from the centre as not only to preserve him from danger, but greatly to facilitate his voyage.

HURRICANE SEASON, INDIAN OCEAN.

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.
2	24	20	46	45	38	34	22	2	2
·04	·52	·43	1·00	·98	·83	·74	·48	·04	·04

This table, deduced from 235 instances, during a period of 27 years, indicates the prevalence of hurricanes in each of the ten months named, none having been encountered in August and September; it should have been inserted between sections 109 and 110, on p. 86. The second line of figures shews the proportion likely to be met with in every other month, January being reckoned as 1·00, or the maximum. [W. R. B.]

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*** The figures immediately following the subject refer to the page—those that succeed, to the section. When reference is made to more than one section, the additional references are enclosed in parentheses.

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